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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

THE INVASION FROM THE AMAZON

Stump of a Giant of the Malayan Jungle Surrounded by Brazilian Rubber Trees

The Honey Locust Contest **Foot Position in Women**

Beginnings of the Rubber Industry

MAY, 1928 Vol. 19, No. 5

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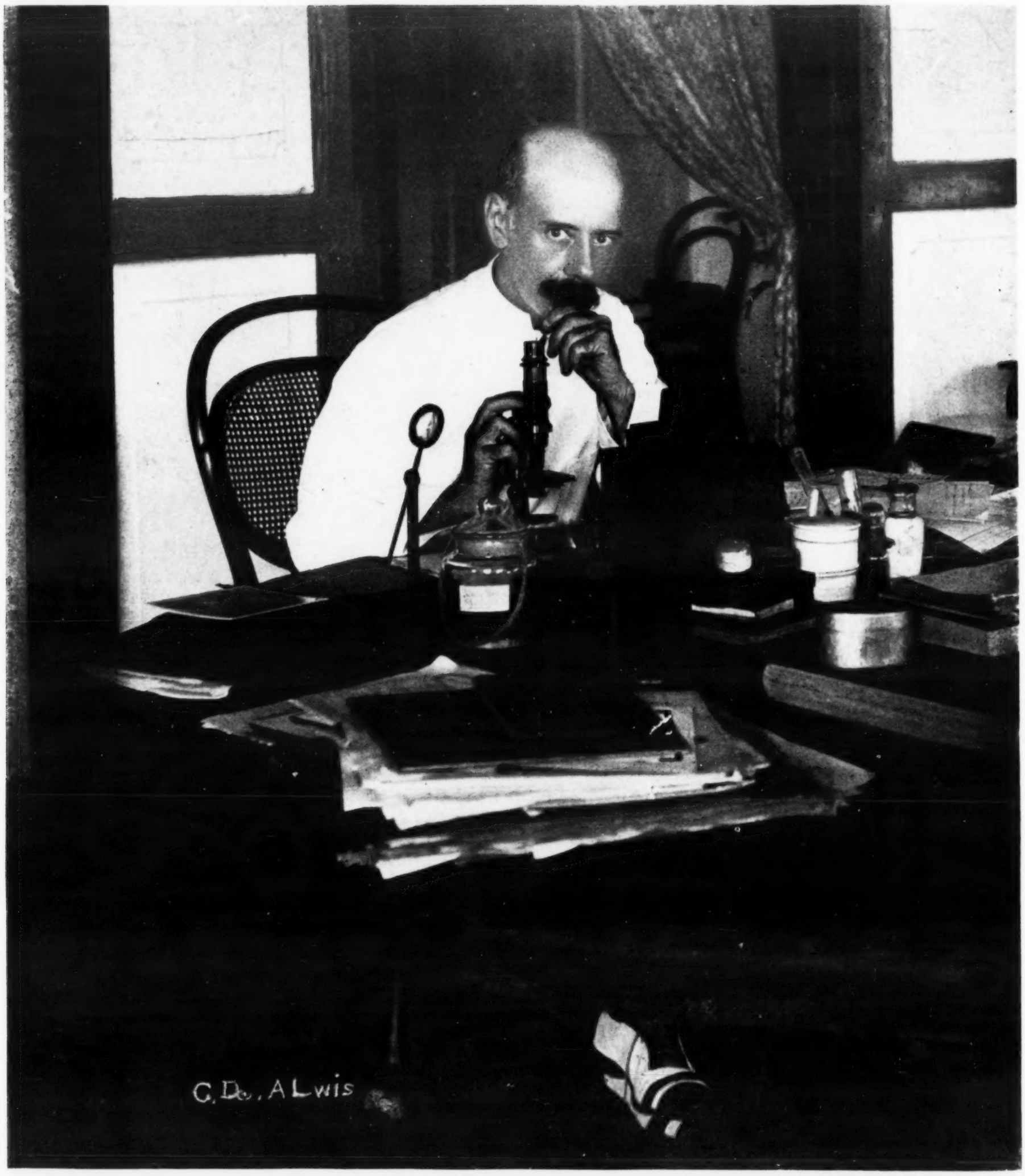

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HENRY N. RIDLEY

Frontispiece

Every inhabitant of the world who travels from place to place on the circular rubber cushions called tires should feel an unusual interest in Mr. Ridley's discovery of the method of tapping the Brazilian Rubber Tree which made possible plantation production of rubber. For his distinguished services in fostering the growing of rubber in the Oriental tropics Mr. Ridley has recently been awarded the Meyer Medal by the Council of the American Genetic Association.

DR. RIDLEY OF SINGAPORE AND THE BEGINNINGS OF THE RUBBER INDUSTRY

The Frank N. Meyer Medal for Distinguished Services in Plant Introduction is presented to Dr. H. N. Ridley for many years the Director of the Botanic Gardens in Singapore in recognition of the important part he played in establishing plantations of the Brazilian Rubber Tree in the Oriental Tropics.

DAVID FAIRCHILD

IT was in the winter of 1896 that I knocked at the door of Doctor Ridley's bungalow in the beautiful Botanic Gardens of Singapore. His veranda, crowded with books, microscope and apparatus, overlooked the garden which he had been in large part responsible for building up. He invited me to spend the day with him and for years afterward the memory of that visit to his bungalow remained as one of the most interesting of a long series of thrilling experiences connected with my travel in the Orient.

At the time of my visit, Doctor Ridley was interested in three things particularly. He had, not long before, been a witness of the murder of the king of a troop of monkeys which he had been watching for years in the garden. Two young male monkeys of the troop had deliberately murdered the old king and usurped his place in the troop. [This observation might be taken as corroborative of the Freudian hypothesis that the "patricidal crime" and the Oedipus complex which brought it about was the beginning of "human culture" had not Malinowski recently shown that another explanation was possible.]

The other natural phenomenon in which he was interested was the most remarkable behavior of a certain species of ant, *Occophylla smaragdina*, which lived in the garden and made nests of the leaves of the trees. It had learned to use its larvae when they reached their spinning stage, much as a seamstress might use an elastic thread, and by means of them fasten together the edges of the leaves which formed the large leafy nest. They were stinging ants, and they worked in gangs on the edges of the leaves; some of them holding the leaf edges together while the others ran the threads of liquid silk over them and bound them fast. My friend, Prof. William Morton Wheeler, tells me that this is one of the most remarkable exhibitions of intelligence, or something akin to it, in the ant world, and Doctor Ridley was the first man to see it and correctly describe it.*

Pioneer of Rubber Planting

But it was the third thing which filled Doctor Ridley's mind most completely at the time of my visit. He was annoyed over the stubborn apathy of the planters of the Malay Peninsula. They refused to see what he considered a great opportunity. The demand for rubber was increasing rapidly and the Brazilian rubber trees were growing perfectly in the garden, yet nobody would plant the seeds from them.

In 1870 Markham had first stirred up the question of transferring the *Hevea brasiliensis*, the best of all the rubber-producing trees, from the Amazon to the East Indies. In 1873 two thousand seeds of this tree had been obtained by the Indian Office from Cameta and from these, twelve

*WHEELER, W. M., Ants, p. 218. RIDLEY, H. N., *Journ. Straits Settlements Branch Royal Asiatic Society*, Singapore, 1890, p. 345.

Photograph by David Fairchild

FIRST TREE AND FIRST TAPPER—CEYLON

Figure 1

Hevea tree planted at Heneratgoda, Ceylon, in 1876. The first tapping is said to have been done in 1882. The presence of latex was established, but it was many years before a new method of tapping was to be discovered that led to plantation culture of Hevea.

plants had been raised at the Kew Gardens and six of them sent out to Calcutta, where they died. Sir Henry Wickham obtained from the Amazon region 70,000 seeds from the Tapajos plateau from which at Kew 7,000 seedlings were raised. Of these a large number went to Ceylon, and two boxes of them to Singapore. This was in 1876. The original plantation at Heneratgoda, Ceylon, of Hevea trees from the 1876 Markham seed, is still standing and the first native tapper there is still alive, and I had the pleasure two winters ago of photographing them side by side.

When I first visited Doctor Ridley, it was after I had been studying in Buitenzorg, Java, where I went with the great botanist, Melichor Treub, and I was imbued with the idea, which I must have gotten from Doctor Treub, that the best tree for the plantations of the Orient must be a native tree and would probably turn out to be the common species of rubber tree, *Ficus clastica*, abundant throughout the East Indies and which did produce a good rubber. This species turned out to be difficult to tap, and today there are only abandoned plantations of it still to be found in Sumatra and Java.

I went from Singapore to Ceylon and saw there what was being done in the Peradeniya Gardens, where they were also interested in the Brazilian tree; but, as I remember the incidents of that time, the storm center of the rubber planting was Singapore and not Ceylon. I am not in a position to document the sequence of events surrounding the work of getting the skeptical planters to devote the fertile acres of their estates to the cultivation of a long lived tree which would have to be handled with some of the care which the dairy farmer devotes to the members of his herd of pedigreed Holsteins; but I do remember this, and I am informed that all are agreed that one of the greatest personal forces in the drive which put the trees of Hevea into the plantations of the Orient was Dr. H. N. Ridley of the Singapore Botanic Gardens.

It was he also, who worked out what is undoubtedly the most important single point of technique connected with the very vital problem of how to get the rubber out of the Hevea trees.

Tapping Method Discovered

It is to Dr. Ridley that we owe the discovery that you can open a wound in the bark of the rubber tree, let it "bleed" and collect the latex as long as it will run, and when the wound dries cut it open again the next day and get not only another run of latex but a larger run than from the original incision. It is this discovery which has led to the development of the modern methods of rubber tapping and, it may be fairly said, solved the planter's difficulties; turned the trick so to say, in a critical period of the rubber industry. Every well informed manufacturer in America will see that such a trick, such a discovery, had it been in the field of patentable inventions would have resulted in royalties sufficient to have enriched the discoverer and placed him in the class of the great inventors of the twentieth century. But it did not do this. Dr. Ridley today is a man of small means whose chief pleasure is in studying the herbarium material which he collected years ago in that part of the world which he chose as a young man for his special field of study—the Malayan Region; and in the preparation of a Flora of that remarkable area of the tropics.

As I have said, I saw him in 1896 in his bungalow. He took me into the garden to show me his grove of Hevea trees, which, alas, has long since been cut down and destroyed.

He said to me as we left the bungalow, "I am taking along a mustard tin. Since you have never tapped a Hevea tree you might like to do so."

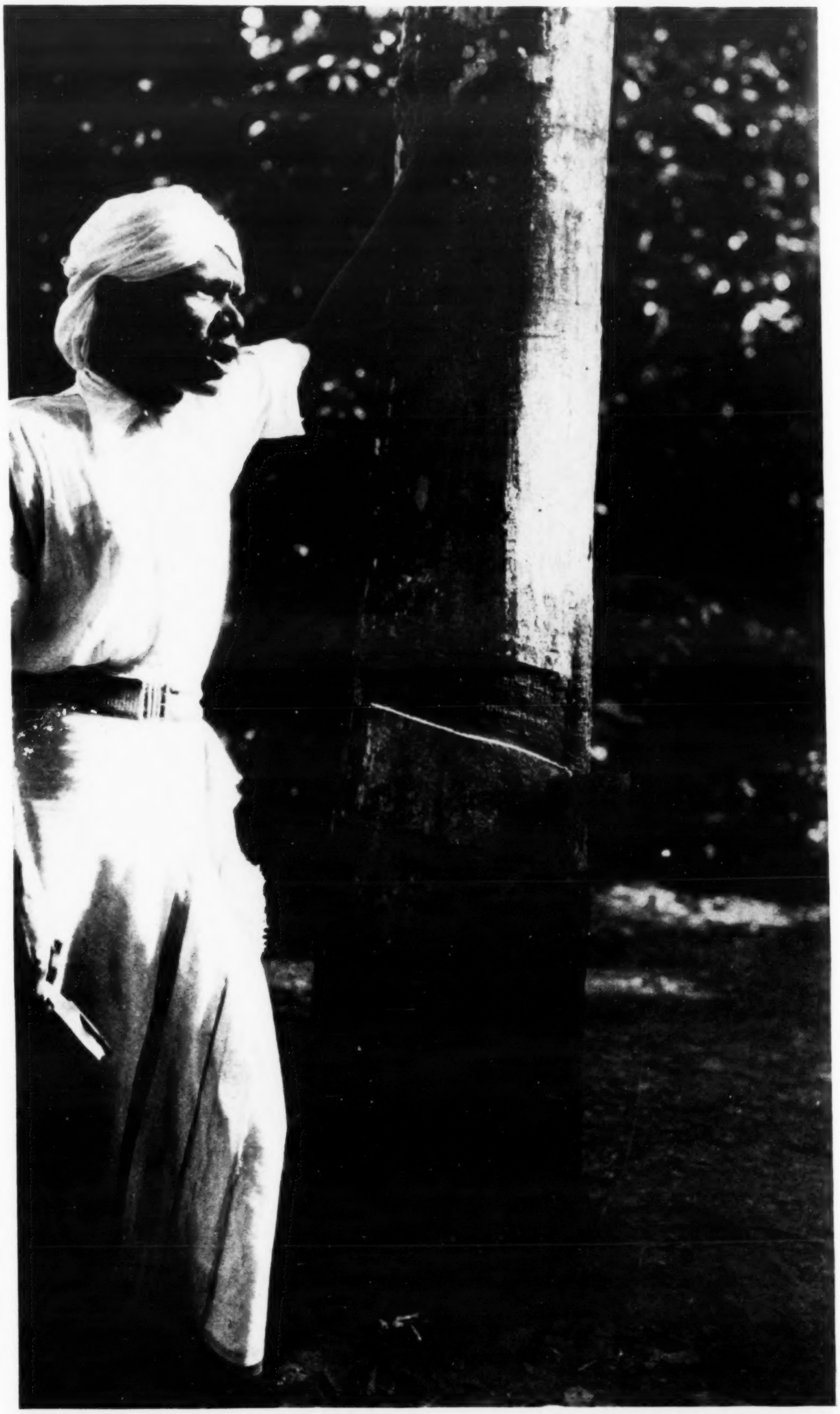
I can see today the stream of milk-white latex as it poured from the in-

Photograph by David Fairchild

A NATIVE TAPPER ON THE FIRESTONE ESTATE—LIBERIA

Figure 2

The Hevea trees in Africa, Australia, Hawaii and Cochin-China, all come from the original importations to Singapore and Ceylon. The Mt. Barclay Estate, which is now owned by the Firestone Rubber Company, was planted in the early years of the present century by an English corporation that later abandoned the venture. Gio tapper on Mt. Barclay Estate, January 28, 1927.



Photograph by David Fairchild

A SINGALESE TAPPER—KANDY, CEYLON

Figure 3

In spite of the controversy as to which of the four introductions of Hevea actually succeeded, this plant from the jungles of the Amazon has had a vast influence on the economic life of the Asiatic tropics. Singalese Rubber Tapper at work, Kandy, Ceylon, January, 1926.

BLACK TRIBES IN THE SERVICE OF KING HEVEA

Figure 4

Ten different tribes among the tappers on the Mt. Barclay Estate of the Firestone Rubber Company in Liberia. Left to right: Grebo, Gola, Gio, Bandi, Buzi, Pessa, Mana, Bassa. Members of the Bandi, Buzi, and Pessa tribes are said to make the best tappers.

cision which Dr. Ridley made in the bark of one of the trees, filling the mustard tin a third full. I took the tin back to my hotel and watched the bubbles form in it as it hardened and became like a piece of cream cheese. I kept it with me and took it to Australia in my baggage and it turned black and became as fine a block of rubber as any one could wish. I used it for years as an eraser in my study and somewhere among my belongings it still exists—the only piece of Hevea rubber I ever collected. As we stood under the trees, Dr. Ridley told me of the apathy of the planters and of his efforts to make them see the coming uses of rubber and the advantages of growing the Hevea in plantations in contrast to the gathering of the rubber from the wild trees as it was done in Brazil, and it is not hard for me to understand that it was primarily the force of his logic and his presentation which convinced the skeptical and indifferent planters and led to the great rubber craze which preceded the gigantic developments of the plantation rubber industry throughout Ceylon, Sumatra, Java and the whole Malayan region.

I cannot get over the fact that I have a rubber eraser which is still good and that the whole vast industry of trees and accompanying paraphernalia of tank steamers filled with the latex, of warehouses and docks, and of millions of rolling rubber tires

has come into existence since I stood beside that great pioneer, while he held a mustard tin, and watched the latex flow into it, which hardened into that black piece of rubber.

The introduction of a new plant into a new region is an "event." The first exploitation and adaptation of that plant to the conditions of life which surround the new plant immigrant is another "event." And we must indeed be lacking in imagination if we fail to raise on a pinnacle the pioneers whose vision and ingenuity and scientific curiosity guide the developments of these vast and indispensable industries during their formative days. The political and military heroes stand out in history and grow great as a result of the "unearned increment of fame" as my friend Frederick Adams Woods has so aptly termed it. The plant men are often modest men who shrink from the limelight and permit themselves to be eclipsed by the great growing horde of self-advertisers whose only object and aim in life is to be widely known.

The occasion of this short article is the bestowal of the Frank N. Meyer Medal for distinguished work in the introduction of plants, upon Dr. Riley, as a tardy and utterly inadequate testimonial of this Association, in recognition of his great work in the establishment of the cultivation of the Brazilian Rubber tree, upon a plantation basis, on the other side of the globe from its original home.

A host of personalities were, of course, connected with this establishment of plantations of Hevea after the initial stages were passed, and by presenting this medal to Dr. Ridley no comparisons are intended. He is today probably the only surviving man whose memory reaches back to the very beginnings of the rubber industry, and this Association takes a peculiar pride in presenting to him the Meyer Medal, which has been intrusted to it for presentation, by the Staff of the Office of Foreign Plant Introduction of the Department of Agriculture of the American Government.

Frank N. Meyer, in whose honor the Medal was cast, was a distinguished Agricultural Explorer of the Office of Plant Introduction who explored the plant resources of Asia for 13 years. and lost his life in the waters of the Yangtse River.

Doctor Ridley was born in December, 1855, in Norfolk, England, and studied at Haileybury School, from which school he went to Oxford, where he studied under the noted zoologist, Ray Lancaster. In 1880-88 he was assistant in the Botanical Department of the British Museum. In 1887 he made an expedition to the Island of Fernando de Noronha. In 1888 he was appointed Director of Gardens and Forests in the Straits Settlements and stationed at Singapore. He has published hundreds of papers and articles on Botany, Biology and Zoology as well as his Flora of the Malay Peninsula.

There are many somewhat conflicting accounts of the early history of the introduction of *Hevea brasiliensis* into the Orient, but the fullest I have seen are in the following publications:

H. N. Ridley, *Straits and Federated Malay States,* No. 8, Vol. IV, Aug., 1905; p. 308.

Mr. Collins, above mentioned, was the first to obtain seeds in Brazil, which were shipped through Mr. Clements Markham to Kew. The few that survived the journey were sent from Kew to Calcutta, where they failed. The next lot, received from Mr. Wickham, went to Ceylon in 1876, and fifty plants were sent to Singapore, where by delay at the docks they perished; next year twenty-two plants arrived safely at the Botanic Gardens, and Mr. Murton took nine plants to Perak for Sir Hugh Low. Much later some more seed was received from Ceylon and grown in the Botanic Gardens. The plant seems never to have been successfully introduced again from South America, and it may be said that all the Para Rubber trees in the Malay Peninsula, and indeed all in cultivation in Africa, Asia and Australia, are descendents of the seed introduced by Kew through Wickham, and, furthermore, all the trees in the Malay Peninsula, except such seeds as have been lately introduced from Ceylon, were derived from the Botanic

THE MEYER MEDAL PRESENTED TO HENRY N. RIDLEY

Figure 5

For distinguished service in establishing the Para Rubber Tree in the Asiatic Tropics. The presentation was made on behalf of the Association and of the Staff of the Office of Foreign Seed and Plant Introduction by Mr. Horace Lee Washington, U. S. Consul General at London, on March 14.

Photograph by David Fairchild

THE INVADER FROM THE AMAZON

Figure 6

In human affairs the introduction of Hevea was a beneficial event: to certain species it was a disaster. Thousands of acres in the East Indies have been denuded of the indigenous flora and planted to this intruder from South America. Here is shown the rotting stump of a giant of the jungle, in midst of 2,400 acres of Hevea trees. Vico Rubber Estate at Langsar.

Gardens of Singapore, which Department has also supplied most, if not all, the plants cultivated in Africa, Mauritius, Seychelles, Borneo, Sumatra, Java, Australia, New Guinea, Polynesia, Hawaii, Mexico, Cochin-China, and other countries.

Though there were a few estates in the Peninsula, like Linsum and Kamuning, which had rubber plantations, no cultivation was commercially undertaken till 1896, when Mr. Tan Chay Yan was induced by the Director of the Botanic Gardens to plant rubber, which he commenced to do at Bukit Lintang, in Malacca and later opened up a much bigger estate at Bukit Ashahan, said to be at present the biggest rubber estate in the Peninsula. Other planters followed suit in 1897, and the success proved so great that new estates are being started every week.

There was no reason why this cultivation should not have been started many years previously. Planters had been strongly advised to turn their attention to this plant, seed of which was freely distributed from the Botanic Gardens, to any who would take it, and samples of prepared rubber from the Gardens' trees were shown at all agricultural exhibitions, but attention was then entirely fixed on coffee, and an unfortunate error, made by a Resident of Perak, caused not only delay in the cultivation but destruction of some of the finest trees in the Peninsula. Some Dyaks had been requested to extract rubber from the Para trees, and not understanding the work failed and declared that the trees were worthless. A number of these trees, which had been planted by Sir Hugh Low at Kuala Kangsa, were on this report destroyed and no planter could be induced to pay any more attention to it till 1896.

"I. H. B." (probably I. H. Burkill) *The Gardens Bulletin* Straits Settlement; Vol. 1. No. 8, p. 252. 1915. "Early Distribution of Para Rubber Plants."

Trimen's 1882 tapping was merely to see if he could get rubber, and in the years immediately following he did not repeat the experiment. But in 1888 he restarted experimental tapping of a modification of the Brazilian method of making numerous small incisions. It is recorded that he tapped but one tree, and that he continued his demonstrations upon it in the years 1890, 1892, and 1894, i. e., in alternate years. These tappings were done timidly for fear of injuring the tree, thus, he made cuts in the tree on seventeen days only in the year 1888, seven being near the commencement of the year, in the months of January and February, six at the middle, in July and August, and four at its close in December. The next tappings were like the first.

* * * *

When he (Ridley) took over charge in Singapore, there existed in the Economic Garden at least nine trees of the row transferred in 1879, twenty-one trees which had been planted in 1884 and were seedlings from the foregoing, or from Kwala Kangsar, thirty trees which had been planted out in 1886, and probably in part came from the Ceylon seed imported in 1885 in a Wardian case, and 1,138 seedlings a year old, and again doubtless from the Gardens' own seed. He at once set to work to care for these, and raised another 8,000 plants from a consignment of Ceylon seed.

He tapped to ascertain yield in 1889 (*Agricultural Bulletin of the Straits and F. M. S.* ix., 1910, p. 202) one year after his arrival, and he reported that the trees "thrive in the damper spots, and those old enough to cut produce a considerable quantity of rubber" (*Annual Report, Botanic Gardens, Singapore*, for 1890, p. 4). Rubber produced from them was exhibited at the Agricultural Show held in 1890 (*Agricultural Bulletin of the Straits and F. M. S.*, ix., 1910, p. 202). To obtain it "the trees were tapped in the herring-bone method," and the latex was collected in cigarette tins and allowed to coagulate naturally "in the tin without the use of acid" (*Agricultural Bulletin of the Straits and F. M. S.*, ix., 1910, p. 202). A pruning knife and a narrow flat chisel seem to have been the implements used in tapping; with the knife the first cut was made and the repeated shaving was done with the chisel, a wooden mallet being used to drive it forwards. One piece of rubber made in these early tappings is preserved in the Botanic Gardens, Singapore, as well as a second of a slightly later date made when saucers were used for coagulation.

Again in the year 1889 an attempt was made to get rubber from the Kwala Kangsar trees, but with no greater success than before, apparently because the herring-bone incision was not wide enough and not reopened, being just an imitation of the method of tapping for Ipoh juice. The great success came in that year—not at Kwala Kangsar, but was Mr. Ridley's. His resort to reopening the wounds was indeed second only in importance as regards the planter to the actual introduction of Hevea into the Old World, and after it the greatest advance that had been made in rubber since the invention of vulcanisation.

I. H. Burkill. The Historical Aspect of Certain Local Industries. *The Singapore Naturalist;* No. 2, April, 1923; pp. 41-43.

The historical data relating to rubber may be condensed as follows:

Sir Clements Markham in 1859, in considering the Cinchona problem, conceived the idea that it was worth while to secure the tree which yielded rubber. In 1870 he formally proposed it and got Collins, Curator

of Pharmaceutical Society of London, who was in the Raffles Museum in Singapore, to collect all the information then available about caoutchouc. That done, the Government of India examined the possibility of improving the India Rubber Fig.

Next, Cross was sent in 1875 after Castilloa to Panama and was ship-wrecked, but got the plants to Kew. Then he went to the Amazon and shipped 1,000 plants of Hevea which he got near Para, and also sent Ceara rubber plants too, returning November 22, 1876, to Kew. Cross' plants of Hevea never reached the tropics. Sir Henry Wickham, residing up the Amazon at Manaos, was commissioned to get rubber seed. He got a cargo steamer load up the Rio Negros and sent thousands of the seeds to Kew, Kew sent the bulk of the seedlings to Ceylon, but two boxes came through Ceylon to Singapore with plants for trial in the gardens there and with a few plants for Buitenzorg. Murton, then in charge of Singapore Gardens, planted them in "Palm Valley" and took some to Kwala Kangsar. Walter Fox, who had conversed with Cross and understood from Cross that the trees about Para are in a swampy situation, transferred the trees to the edge of the low ground in the Economic Garden. Cantley, who succeeded Murton, watched them growing there, but wrote that with the rubber vine within the forests of the Peninsula there seemed to be no call for plantation trees. Mr. Ridley halted in Ceylon on his way to Singapore in 1888 and saw Trimen, the Director of the Peradeniya Garden, tapping very cautiously; then coming forward to Singapore, he too tapped; and it chanced that on one occasion men accustomed to tap for *Ipoh* poison were used; the result was a bolder tapping, but yet timid. The bolder, however, it got, the more profitable cultivation came into sight, and the greater grew his advocacy. At length Malayan rubber could be sold on the London market and the case was won.

No Change in Metcalf Will Case

Since the publication of Mr. Metcalf's will in the March number no important developments have occurred. It was reported at one time that the case would be brought before the May session of the Court at Buffalo, Wyoming, but now we are informed that it will not be called before the fall term. The Association is represented by Mr. C. A. Kutcher of Sheridan, Wyoming, and by Mr. Stanton Peelle of Washington.

The publication of the text of the will has brought forth a number of comments as to the eugenic value of the views expressed by Mr. Metcalf. It is hoped that some of these, at least, can be published in an early number of the Journal.

Arrangements are also being made to obtain for publication in the Journal of Heredity an appreciation of Mr. Metcalf, who acquired and expressed such clear views of the importance of heredity during a busy life spent in pursuits little related to genetics.

BEGINNINGS OF RUBBER CULTURE

Special Characters of the Hevea Tree Determine Method of Tapping

O. F. Cook
Bureau of Plant Industry

IT seems remarkable that events so recent as the development of rubber culture should be difficult to trace, in view of the extensive literature and the large possibilities recognized from the beginning of the undertaking. Conflicting testimony has been given by different writers, and the development of the tapping method for Hevea has remained obscure. Doubtful points may still be cleared by finding additional documents to show more definitely the course of events, and confusion may be avoided by more careful consideration of the biological facts.

Incidents of no importance in themselves show the vicissitudes of the rubber undertaking, even with the best facilities that could be provided at the time by the country with the greatest colonial interests. Without the system of botanic gardens in England and in the colonies, the establishment of the rubber industry might have been delayed for many years, or developed in other parts of the tropics. Even with the facilities that existed, the success of the undertaking was by no means assured, since the practical outcome seems to have depended very largely upon the special contribution of one man, as Dr. Fairchild has appreciated in the recognition extended to Dr. Ridley.

Notwithstanding that the rubber introductions were considered as of potential importance from the first, they remained subject to the same kinds of errors and accidents that usually are encountered in the handling of plant material. The history shows how thoroughly accidental were the discoveries that finally opened the way to plantation production of rubber. Two introductions of the Para rubber tree failed completely, and the third would have been of as little use if a special method of tapping, different from that used in Brazil and better adapted to plantation purposes, had not been developed.

The lesson to be learned from such experience is that the introduction of plants to new regions, though often a difficult undertaking in itself, is only one of many steps or stages in the development of new industries.

The First Prophet of Rubber Culture

The first writer to foresee the establishment of rubber plantations as a practical possibility of the future seems to have been James Howison in an article entitled: "Some Account of the Elastic Gum Vine of Prince of Wales Island, and of Experiments Made on the Milky Juices Which It Produces: With Hints Respecting the Useful Purposes to Which It May Be Applied, published in 1798.

Collins refers to Howison as the first to discover in the Old World "a plant yielding caoutchouc," as though the Eastern Hemisphere had no rubber in use. It is interesting that Howison does not claim an original discovery, but refers to rubber articles made by the Chinese, just as the early explorers report rubber balls and other objects in use among the natives of America.

> This extraordinary vegetable production, in place of being injured by water, at its usual temperature is preserved by it. For a knowledge of this circumstance I am indebted to the *Chinese*. Having some years ago commissioned articles made of the elastic gum from *China,* I received them in a small jar filled up with water, in which state I

have since kept them, without observing any signs of decay.*

Howison's suggestion of rubber plantations in India and introducing "the American tree," is made in the following paragraphs:

> Greatest attention must be paid to prevent one part of the gum coming in contact with another while wet with the milk or its whey; for the instant that takes place, they become inseparably united. But should we ever succeed in having large plantations of our own vine, or in transferring the American tree (which is perhaps more productive) to our possessions, so that milk could be procured in sufficient quantity for the covering of various cloths, which should be done on the spot, and afterwards exported to Europe, then the advantages attending this singular property of the milk would for ever balance it disadvantages: cloths, and coverings of different descriptions, might then be made from this gum cloth, with an expedition so much greater than by the needle, that would at first appear very surprising: the edges of the separate pieces only requiring to be wet with the milk, or its whey, and brought into contact, when the article would be finished, and fit for use. Should both milk and whey be wanting, a solution of the gum in ether can always be obtained, by which the same end would be accomplished. . . . .
>
> Should it ever be deemed an object to attempt plantations of the elastic gum vine in Bengal, I would recommend the foot of the Chittagong, Rajamhal and Bauglipore Hills, as situations where there is every probability of succeeding, being very similar in soil and climate to the places of its growth on Prince of Wales's Island. It would, however, be advisable to make the first trial at this settlement, to learn in what way the propagation of the plant might be most successfully conducted. A further experience may also be necessary, to ascertain the season when the milk can be procured of the best quality, and in the greatest quantity, with the least detriment to the vine.*

Following this article by Howison is a botanical account of the rubber vine by William Roxburgh. The discovery is credited to "Mr. Howison, late Surgeon at Pullo-pinang," and the vine is described as a new genus and species, *Urceola clastica*. This description of the "East India Caout-chouc" and the account of the Assam rubber tree, *Ficus clastica*, in Roxburgh's "Flora Indica," based on materials obtained in 1810, may be considered as the beginning of the scientific study of rubber plants. Roxburgh also made experiments with the rubber of Urceola, and states that it "rubs out the marks of a black lead pencil as readily as the American, and is evidently the substance of which the Chinese make their elastic rings."

Another writer who projected the idea of rubber culture far in advance of the actual undertaking, was Thomas Hancock, the first large-scale manufacturer of rubber goods in England, and author of many patents developed from his experiments. As early as 1824, Hancock imported rubber latex from Central America and worked out many uses of the "liquid rubber," but the difficulty of obtaining regular supplies of the material proved too great. The future importance of rubber as a necessary industrial material is clearly implied in Hancock's reference to plantation possibilities.

> I some time since, through the medium of the "Gardener's Chronicle," called attention to the possibility of cultivating the best kinds of caoutchouc-bearing plants in the East and West Indies: the Siphonia elastica of the river Amazon, the Hancornia speciosa of Pernambuco, and the Urceola elastica of Borneo, Pulo-Penang, and other islands. From the best information I have been able to obtain there is every probability of success, and as this substance is now become an article of large and increasing consumption, plantations of these trees may in a few years produce a beneficial return. We cannot look far into futurity, but if by any chance the present source of supply should be cut off or obstructed, another source would be of great importance; at all events the subject should not be lost sight of, and I mention it here in the hope that the suggestion may meet the eye of some one who may be disposed to make the trial. Sir W. Hooker has been so kind as to say that he would at any time render any assistance in

*These paragraphs are quoted from the fourth edition of *Asiatick Researches*, 5:157, published in London, 1807. The first edition is dated 1798.

his power to parties disposed to make the attempt.*

Markham Promoted Introduction

The original interest and initiative of the rubber introduction is credited by most of the historical writers to Clements R. Markham, who attained distinction and knighthood for the introduction of the Cinchona trees, that are the source of quinine. Markham was commissioned for the Cinchona work by the Government of British India in 1859. In the next year the Cinchona districts of eastern Peru were explored to obtain seeds and seedlings of the best kinds, and then Markham went to India to locate the best district for Cinchona plantations. The success of the Cinchona introduction was announced in Markham's "Travels in Peru and India," published in 1862. Another book called "Peruvian Bark," was published by Markham in 1880, with an appendix on "Caoutchouc Cultivation in British India," which explains how the introduction of rubber trees was a development from the quinine introduction.

Markham dates from 1870 his recognition of the need of similar work being done with rubber-producing plants, and indicates that the plan was adopted through his interest with the Government of India. The first step was to bring together all of the existing information relating to the rubber-producing plants and the methods of extracting and treating rubber latex. This task was entrusted to James Collins and his report on the "Caoutchouc of Commerce," published in 1872, may be considered as the beginning of the introduction project.

Collins had published previously in 1868 and 1870 two important papers, "On the Commercial Kinds of India Rubber or Caotchouc," and "India Rubber, Its History, Commerce and Supply." The second of these articles, read before the Society of Arts on December 15, 1869, concludes with the following paragraph which suggests that the contact with Markham was being made.

> In closing these remarks, there is one subject which I would more especially recommend to the attention not only of those present, but also submit to the attention of her Majesty's government, that is, the acclimatisation of the different species of *Hevea* (and also incidentally I would mention the species of *Isonandra*, which yield gutta percha) in such of our eastern possessions as will be found best suited. The introduction of the invaluable cinchonas into India has been attended with marvellous success, and is alike an honour to this country at large as to those scientific men who have been engaged in the undertaking. Though I would not plead an equality of value in these articles, yet all will agree that fine descriptions of India-rubber are sadly needed; that increasing supplies do not seem to be forthcoming; and that the Para rubber, furnished by the species of *Hevea*, is superior to any other†

Neither Markham nor Collins appears to have done any actual work with rubber trees, either in South America or in the East Indies, but some of the men who were associated with Markham in the quinine investigations took part in the introduction of rubber. Richard Spruce, who had spent several years in botanical explorations along the Amazon, under a commission from the Kew Botanic Gardens, was engaged in 1859 to study the quinine trees of the eastern slopes of the Ecuadorean Andes. Spruce already had collected much botanical information and material of different species of Hevea, as well as information on the methods of gathering rubber. Some of the information from Spruce was included in Collins' report,

*Personal Narrative of the Origin and Progress of the Caoutchouc or India Rubber Manufacture in England by Thomas Hancock, 1857. pp. 76-77. The date indicated for the reference to the *Gardeners' Chronicle* is 1834, but that journal was not established till 1841. Other horticultural journals of that period have been consulted, but without finding such an article.

†*The Journal of the Society of Arts, and of The Institutions in Union*, December 17, 1869, No. 887, Vol. XVIII, Page 91.

and served no doubt to stimulate interest in obtaining seeds of Hevea from Brazil.

Another of the quinine explorers was Robert Cross, who went later on two expeditions for rubber. The first expedition was to Panama in 1875, to obtain seeds of Castilla, and the second expedition to Brazil in 1876, for Hevea, Manihot and Hancornia. Markham and Cross apparently would have had all the credit that is now extended to Wickham for the introduction of Hevea, as the plans for such an introduction not only were definitely made before Wickham's shipment of seed was received in England, but were actually carried out. Markham states that Cross sailed for Brazil from Liverpool June 19, 1876, a few days after Wickham's seeds reached Kew. Markham describes in some detail the work done by Spruce and Cross, but has nothing to say of Wickham's introduction.

This omission might seem to be explained by a statement of Petch, that Wickham was commissioned directly by Sir Joseph Hooker, Director of the Kew Gardens, to obtain Hevea, which would indicate that Cross and Wickham were working on separate projects. Petch states also that Wickham reached Kew on June 14, 1876, that the Hevea seeds were planted on the following day, and that some of them germinated the fourth day after sowing. The number that germinated is given by Petch, on the authority of Trimen, as 2700, while Wickham states a much higher figure.

June, 1876, was a time of commotion at Kew, as they were compelled to turn out orchid and propagating houses for service, and to make room for the sudden and all-unexpected inroad of the *Hevea;* but Sir Joseph was not a little pleased. The *Hevea* did not fail to respond to the care I had bestowed on them. A fortnight afterwards the glass-houses at Kew afforded (to me) a pretty sight—tier upon tier—rows of young *Hevea* plants—7,000 and odd of them.

Discussion then ensued at the India Office as to their disposal. Sir Joseph Hooker, together with Sir Clements Markham, at that time at the India Office, recommended the carrying through of the suggestions and recommendations of my reports—that was to say, concentration of the greater bulk of the young *Hevea* seedlings, on a given locality, Tenasserim, Southern Burma. Then came the fall of the rupee to depreciation. Requisitions in forestry were cut, and my special item among the first. Meanwhile, the young seedlings were growing apace in the Kew glass-houses; and so it was determined that they would be best dispatched to the Eastern Tropic Botanic Gardens—mainly to Ceylon—as affording the best equipment. Being placed under charge of a Kew man, they were put up in wardian cases, and dispatched down the Thames by barge to British India liners at the river mouth.*

Wickham also claims for himself and for Sir Joseph Hooker a prior interest in the idea of introducing Hevea, and states that Hooker interested Markham in the project.

My personal working acquaintance of the tropical American rubber forest trees stretches back into the sixties; but I was at that time as one before my time—as one crying in the wilderness. Dead weight of inertia, not to say opposition, prevailed. The idea of cultivating a "jungle forest tree" was looked upon as not less than visionary. Association of British produce brokers looked with unfriendly eye upon the notion of cultivation of what had come to be regarded as one of the staple "raw material" world-products. Fortunately, there was in Sir Joseph Hocker, of Kew, a man who looked upon the matter in another light. He had, indeed, even then and for some time, been giving it thought, and had been endeavoring to obtain the introduction of the trees for the Government of India. Thus was I enabled to elicit his attention and support. He was first attracted by my drawing of leaf and seed of the tree appearing in a volume of *Rough Notes of a Journey through the Wilderness*, published in 1871.

Sir Joseph Hooker, himself become keen on the project, further interested Sir Clements Markham, at that time at the India Office; and so a Commission for the introduction of "the tree which produced the true 'Para' rubber of commerce" was given by the Government of India. At the same

*Wickham, H. A. "On the Plantation Cultivation and Curing of Para Indian Rubber." pp. 54-56.

time, fortunately, I was left quite unhampered by instructions as to way or means. A straight offer to do it; pay to follow result.*

Thus it appears that Wickham's commission came from the India Office through Markham, and that Hooker and Markham were working together, instead of separately. Yet this does not make it easier to understand why Markham, writing in 1880, should not have referred to the Wickham introduction as well as to the work of Cross.

It also seems remarkable, in view of the importance attained in recent years by the East Indian rubber industry, that no reference to the rubber introduction is found in the biography of Markham, written by his son, which was published in 1917. Markham gathered laurels in so many other fields, as geographer, botanist, historian, archæologist and ethnologist, that the rubber incident may have escaped notice.

Fate of the Cross Introduction

The statement that the plants obtained by Cross did not reach the East Indian tropics apparently is not to be relied upon. Indeed, it is suggested in a recent paper by Mr. Ridley that the 22 plants sent from Kew to Singapore in 1877 probably were Cross's plants, "and not Wickham's at all." This is a question of possible significance, as the plants obtained by Cross were from the lower Amazon, not far from Para, not from the up-river districts, where the seeds of Wickham's importation were collected.

Most of the Hevea trees in the East Indian plantations are supposed to have come from the shipment that went to Singapore in 1877, which was sent to replace the shipment of the previous year of plants of the Wickham stock, that had been allowed to die on the dock at Singapore. But it is also questioned whether some of the plants of the shipment of 1876 did not survive. Petch refers to a letter from Murton, under date of September 6, 1877, "to the effect that the Hevea sent last year (i. e. 1876) were making good growth."†

Also there seems to be no definite record to show whether the shipment of 1877 from Kew to Singapore was really of the Cross stock, or a small hold-over of the Wickham material. Thus the true origin and composition of the first stock of Hevea, established at Singapore and later increased to such vast proportions in the Malay Peninsula remains in doubt. The shipment of 1877 reached Singapore in June. Plants taken by Murton to Perak in October doubtless were of the lot that had recently arrived, but this does not preclude the existence of another lot obtained in the previous year, so that two introductions would be represented at Perak as well as at Singapore.

Two Previous Introductions

An apparently complete loss of the first introduction of Hevea, made in 1873, is a feature of the rubber history that should not be ignored in the study of such problems. A shipment of 2,000 Hevea seeds from a place called Cameta, southwest of Para, reached Kew June 4, 1873, but only a dozen plants were raised. Six of these seedlings were taken to Calcutta in September of the same year. "They were propagated by cuttings both at Calcutta and Kew."‡ The stock at Calcutta gradually died, though Ridley indicates that plants were sent to South Burmah, "and possibly their descendants are there to this day." This also

*Wickham, H. A. "On the Plantation Cultivation and Curing of Para Indian Rubber." pp. 45-47.

†Petch, T. *Annals of the Royal Botanic Gardens.* Peradeniya, Vol. V., Part VII, September, 1914, pp. 440.

‡Several other references to propagation by cuttings are found in the early publications, which seems the more remarkable in view of the failure to propagate Hevea by cuttings since that time.

seems to be indicated by the following statements by Petch:

> Hevea was first planted at Mergui in 1877, when eight seedlings, the survivors of a small batch received from Dr. King, the Superintendent of the Royal Botanic Gardens, Calcutta, were planted out in the Forest office compound. . . .
>
> Hearsey states that of the eight seedlings planted in the Forest office compound at Mergui (now the Mergui Municipal School), two were alive in 1906. Their girth was about 5 feet. They were tapped as an experiment in 1902, when 2½ lb. of dry rubber was taken from each*

Petch also traces the history of a larger consignment of Hevea plants from Ceylon, that reached Mergui in 1879, which were planted in another place. Seedlings were raised from "a few of the older trees" in 1884, but from which lot of trees is not definitely indicated.

A second effort to bring Hevea seeds from Brazil to Calcutta was made in 1875, but was reported as a complete failure. The only information is the following statement from a report of the Superintendent of the Botanic Gardens, Calcutta, quoted by Petch:

> It was with much regret therefore that I had to report to Government the utterly hopeless condition of a large consignment of Hevea seed sent out by the India Office during September last. This consignment was packed in large barrels, a singularly unfortunate arrangement for such oily and perishable seeds as Hevea. (Petch, p. 439.)

Thus the seed brought by Wickham in 1876 represented a third importation from Brazil, and the plants obtained later in the same year by Cross marked a fourth effort.

In the previous year Wickham also had sent to Kew two small lots of Hevea seeds, but all had failed of germination. Thus he was well aware of the perishable nature of the seeds, and the need of special precautions to bring them home alive. Wickham's exploit in 1876 in chartering a tramp steamer on the Amazon to take a cargo of Hevea seeds direct to Kew, placed the introduction on a practical footing. The correspondent who brought the first Hevea seeds to Collins from Brazil in 1873 was named Farris, and the plants that reached India in that year were carried by Sir William King, Director of the botanic garden at Calcutta. Hence Farris and King are credited by some writers for the rubber introduction, instead of ascribing it to Collins, Markham, Cross or Wickham. Others give the chief credit to Sir Joseph Hooker, the Director of the Kew Gardens, as the central figure of the undertaking.

Tapping Experiments in Singapore

The tapping of the rubber trees in Singapore is dated from 1889, but the information obtained by Dr. Fairchild in 1896 was a year in advance of the first statement that was published by Ridley, in 1897. The report of the Singapore Botanic Gardens for 1889 has no mention of rubber tapping experiments, and only brief references are found in the reports of 1890 and 1891; enough to show that the trees were being tapped, but with no indication of the method used.

> The Para-Rubber trees continue to thrive in the damper spots, and those that are old enough to cut, produce a considerable quantity of rubber, which appears of good quality. Samples have been sent to England for analysis. If the quality is satisfactory, this plant will be well worthy of cultivation in many spots of damp waste land in which few other crops can be grown without great expense in draining. (Report for 1890, p. 4.)
>
> Para Rubber (*Hevea braziliensis*, Spruce) seeds were obtained from Kew and from the trees in the Experimental Garden, and a large number of plants raised. Eight acres of this valuable India rubber tree have been planted this year at Sumbawang, and the trees are thriving remarkably well. Rubber collected from the trees in the Experimental Garden was pronounced by Messrs. Silver to be of very good quality. Fast as this plant grows, it will be nearly ten years before it is at the best stage for tapping. More seed is urgently required. (Report for 1891, p. 9.†)

*Petch, T. Notes on the history of the Plantation Rubber Industry of the East:—*Annals of the Royal Botanic Gardens.* Peradeniya, Vol. 5, 1911-1914, pp. 486 and 487.

†Annual Report Straits Settlement, Royal Botanic Gardens, for the Year 1890 and for the Year 1891, by H. N. Ridley.

The reports of later years refer to other plantings of Hevea, and to the distribution of seeds, but it is not till the report for 1897 that any reference is made to experiments with tapping.

A considerable part of the hill in this Garden was cleared, dug and planted with grass, and some fresh land was opened in the swampy portion near the ramie beds, but the greatest amount of labour was expended in clearing the scrub around the Para rubber trees. This had grown up so high as to make it impossible to find the seeds of the trees, which fell among it.

The demand for plants and seeds of Para rubber was greatly in excess of the supply, but 21,035 plants and 10,875 seeds were supplied to planters in Singapore, Selangor, Malacca, Pahang, British Borneo and elsewhere. Various experiments were made as to methods of progapation, tapping and yield of rubber, the results of which have been published in a bulletin on the subject. A large number of planters and others interested in the cultivation of this plant from different parts of the Peninsula, Java, Sumatra and Borneo visited the Garden to see the rubber trees and the various methods of cultivation and preparation of the rubber.

The bulletin on rubber was published in June, 1897. The traditional herring-bone form of cut is indicated, with no resemblance to the modern panel form, and it still was believed that only narrow cuts could be made. But the new feature of repeating the same cuts is definitely stated, and the way was opened to all of the subsequent evolution of the tapping forms, leading eventually to the simple panel cut of present tapping practice. The new mutation of tapping methods was brought to light in the following statement:

The tapping is best done in the following way. A number of oblique cuts are made in the bark converging to a central vertical cut, at the bottom of which a cup is placed. The rubber runs down the cuts into the central one which conducts it to the cup.

The cuts should be made through the bark, which is about a quarter of an inch thick, but so as not to injure the wood, and should not be made more than a half an inch wide. Their length, six or more inches, will depend on the thickness of the tree. These cuts may be re-opened a day or so later and more rubber will come out. It is best to make a small groove at first, cutting a thin slice off the edge of the wound each day till the groove is about half an inch wide. The wounds heal up in a few weeks if not too wide. . . .

The exact amount of rubber which can safely be drawn from a tree is not yet settled experimentally, but two pounds may be safely counted on for a year's tapping of a five or six years old tree if well grown, and it is probable that a larger quantity than this can be taken without harm. Of course much depends on the size of the tree, which again depends on the soil and position in which it is grown. Further experiments are being made on this point.

A tree nine years old was tapped, April 20th. It was about forty feet tall and a foot through at the base. Cuts were made in it, the edges of which were sliced again every day for a week. The first cut yielded half a pound, and the whole result gave one pound fourteen ounces. Now (June 17), the wounds are partly callused over and the callus already contains rubber.*

Range of Tapping Extended

The method indicated by Ridley of reopening the same cut was also being used by Curtis at Penang, as shown by his reports for 1897 and 1898. The garden at Penang was conducted as a branch of the Singapore Garden, and the statements by Curtis gave more detailed information on the method of tapping.

The soil of this garden is by no means the kind that I should choose for planting Para rubber, as it is dry and gravelly, but there are a few trees here that were planted in 1886. The largest of these has a girth of about thirty-six inches at three feet from the ground, and as many inquiries were received respecting the quantity of rubber to be obtained from a tree, etc., this one was tapped as an experiment in June. The first day's collection yielded only half an ounce, but by renewing the cuts on seven subsequent occasions, one pound of dry rubber was obtained, being an average of two ounces for each tree. This is very poor, compared with the results obtained in Singapore and in Perak, but, as I have already mentioned, the tree is growing in unsuitable soil, and the weather was at the time very wet. The climate appears to suit this tree, and the only important item of expenditure after a plantation is once established is the cost of collecting. (Report for 1897, Page 7.)

*Ridley, H. N., *Agricultural Bulletin of the Malay Peninsula.* No. 7, June, 1897, pp. 136-8.

On the morning the incisions were first made only ¼ oz. of wet rubber was obtained, but by taking a thin shaving off the lower surface of the oblique cuts on fourteen subsequent occasions the following quantities was obtained at each operation in ounces: ¾, 1¾, 3¼, 3½, 3¼, 6, 9, 6½, 8½, 6, 6½, 10, 8½, 8. Total 5 lb. 1½ oz. of wet rubber which weighed when dry exactly 3 lb. As will be seen from this the last three tappings gave a better result than any previous three, and operations were only suspended as it was not advisable to make the cuts any wider. The time occupied in affixing the tins and renewing the cuts averaged half-an-hour on each occasion, or seven-and-a-half hours in all. It may therefore be taken that a man at say 30 cts. per day could attend to at least fifteen trees per day and that the cost of collecting will not exceed 10 cents per lb. (Report for 1898, Page 10.)

The intervals between the successive tappings are not indicated, but the 15 tappings covered a period of 34 days. The higher yield from the later tappings of the series is definitely shown.

Wound Response Recognized in Ceylon

The development of the tapping method at Singapore undoubtedly was obscured by the announcement a little later from Ceylon of an important discovery in regard to the tapping of Hevea trees. A different method of tapping was being tried in Ceylon, with separate new cuts between the previous cuts, as practiced in Brazil. The discovery of the "wound effect," as it was called at first, was taken to indicate that the separate-cut method was preferable to Ridley's method of paring the margins of the wounds.

The great thing is to use the "wound effect" by making new wounds near the old after an interval of say six or seven days. The old wound may be "renewed" with a knife several times, and a good yield is obtained thus, but the final result is liable to be a very ugly wound in the tree, which may lead to decay or other injury.

We do not yet know the conditions under which this "wound reaction" works, and it is probable that much will yet be found out about it: probably it will be found that under some conditions it is best to tap daily, while under others it is best to tap at intervals of two, three, four, seven, or even ten or twelve days.*

Willis also, in 1898, had observed that the second tapping yields more than the first, with separate cuts at intervals of a week, the method used by Parkin.

The tappings may follow one another at intervals of a week for about four to eight weeks. The second tapping gives a much larger yield than the first, and the third and fourth tappings are usually very productive. In a series of experiments made during 1897 on trees of about 2 ft. mean girth, the average yield per tree of the successive weekly tappings was as follows:

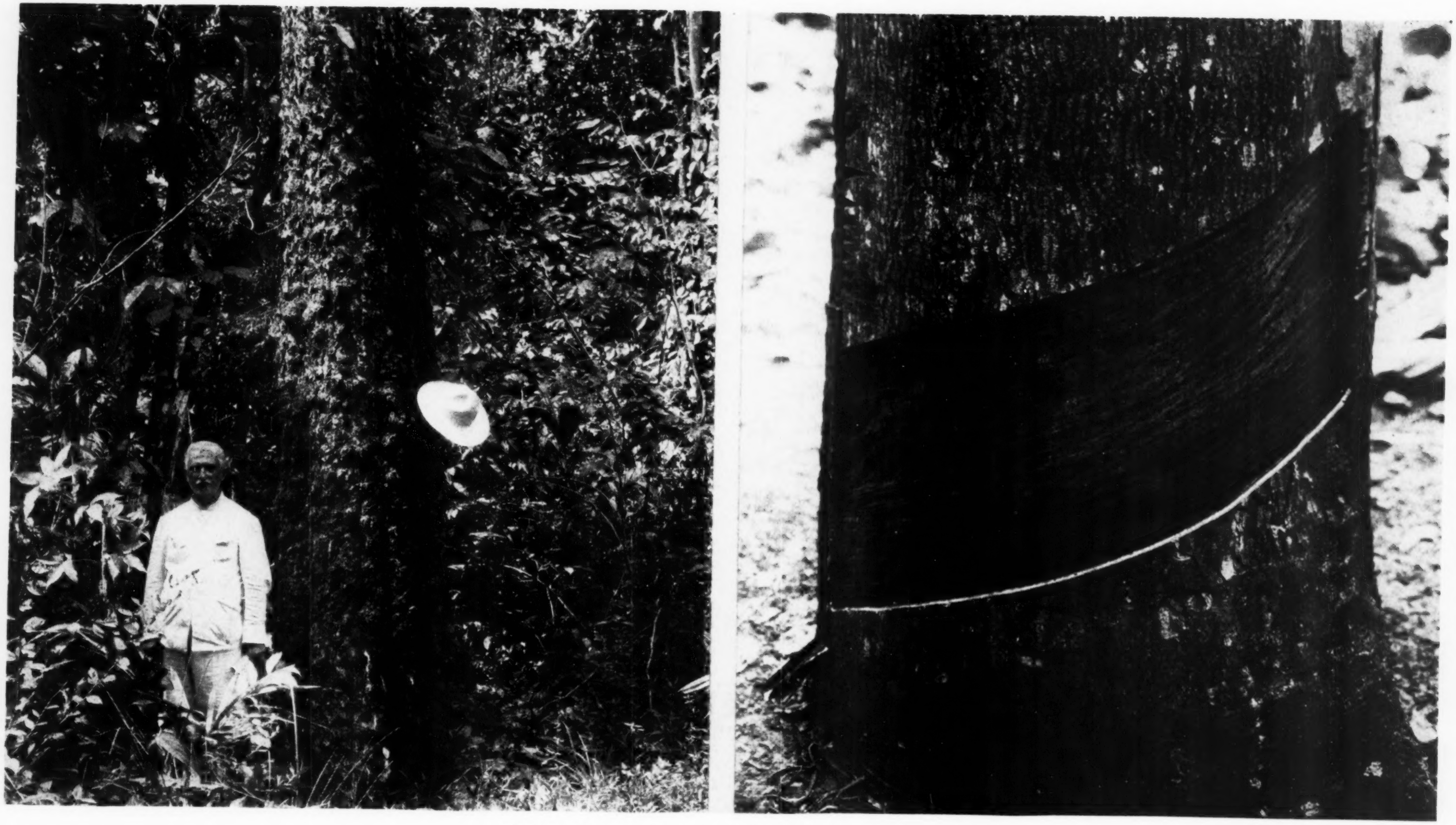
	Oz.
First week	.73
Second week	1.48
Third week	.97
Fourth week	.80
Fifth week	.67
Sixth week	.52
Total	5.17 oz.†

This statement by Willis, with those previously quoted from Ridley and Curtis, make it plain that wound response already had been witnessed by at least three experimenters, but without being recognized as a very peculiar and important feature in the physiology of the Hevea tree, which Parkin had at once appreciated, and hastened to announce.

Notwithstanding its scientific interest, the discovery of the wound response of Hevea did not serve at once to establish the new tapping method, but seems rather to have occasioned a certain confusion in the minds of the experimenters. Parkin began by objecting to Ridley's method as likely to injure the trees, while Ridley could not admit the claims of special value for the method that Willis and Parkin were using when the wound response was brought out. An experiment noted by

*Parkin, J. Circular, Royal Botanic Gardens, Ceylon, Series 1, Nos. 12, 13 and 14. June 1899, pp. 140.

†Willis, John C. *Circular, Royal Botanic Gardens, Ceylon, Series* 1, No. 4, January 27, 1898, p. 32.



TWO METHODS OF TAPPING HEVEA

Figure 7

On the left an old Hevea tree in the forest in Brazil, the trunk very rough with protuberances that result from the native method of tapping, by many separate incisions. At the right, a Hevea tree in Haiti with a modern panel cut formed by tapping continuously in the same place, by par-
from U. S. Department of Agriculture Bulletin 1422, October, 1926, *The Hevea Rubber Tree in the Amazon Valley*, by Carl D. La Rue.

Ridley in 1903 confirmed his adverse opinion of the Ceylon tapping method, with small separate incisions, though the incisions in this case seem to have been reopened, instead of making new incisions between.

Much has been said of the advantage to be derived from the reopening of fresh wounds, giving rise to that phenomenon often alluded to as the "wound effect." On the advice of Mr. W. W. Bailey, of Lowlands Estate, Klang, who witnessed the tapping one morning, this experiment was tried. On the 16th of April one hundred trees gave a yield of 80 oz. of pressed rubber. On the 18th of April, the incisions made (four to each tree) on the 16th of April, to the hundred trees were reopened resulting in 58 ¾ oz. of pressed rubber, or a sudden drop of 21¼ oz. This certainly seems to point out that reopening an old wound is not to be recommended.*

The discussion was continued in 1910 in a longer statement by Ridley, which recognizes that the wound response had figured in the tapping experiments as conducted at Singapore, and is an essential feature of the tapping method, though still objecting to the idea that the discovery of the wound response had served as the basis of the development of the new system of tapping.

Needless to state we discovered what is now called "wound response" shortly after we commenced tapping in 1889, but from some Brazilian seringueiros who visited the Gardens later, I found that it was well-known to them, so did not record it as an important discovery on my part. At that time the preliminary tapping before taking the latex on the second day was called "Calling the rubber," and when samples of rubber were required for any purpose a man was sent to "call the rubber" two or three days beforehand. At this date, twenty years since I commenced tapping the rubber trees I cannot remember when I actually discovered the wound-response for myself.

Many planters and agriculturists, and Dr. Trimen himself, visited the Gardens in these early days, and the advantage of rubber as a crop was urged on them. They were shown the trees, system of tapping and specimens, and the necessity of "calling the rubber" before collecting in bulk was explained to them, and they often carried away with them samples of the prepared rubber. Many of them came from Ceylon or had intimate relations with Ceylon. All this was going on some years before Mr. Willis or Mr. Parkin came to the East at all, or had seen a rubber tree.

Mr. Wright, in talking of Mr. Willis' discovery of "wound response," (this word indeed seems to have been invented by Mr. Parkin or Willis, but it does not occur in Parkin's first account of his experiments) says that it is of great practical importance in the rubber cultivation, and also of great botanical interest. I fail to see where the great practical importance comes in, at present; we knew of it all along, and the chief value of its knowledge was that in early days a few ignorant people who attempted to tap a tree one day, and did not find the rush of latex at first that they expected, thought, till they knew of it, their trees were useless. Should we, however, find out the real meaning of it we might gain some knowledge of the functions and the physiology of latex which could not fail to be of value, but at present we are not much wiser today on this subject than we were in 1890.†

Discovery of Ibidem Tapping

Some of this confusion and misunderstanding might have been avoided if the tapping method had been stated and described as a scientific discovery, as it undoubtedly was, as well as a practical step in the establishment of rubber culture.

The Hevea tree is peculiar in having a bark of special texture and vitality, so that the injury from cutting affects only the immediate surface of the wound and remains entirely superficial. The wound response is remarkable, but is not the whole story. The lack of fibers in the bark of Hevea, and the rather soft, uniform consistency of the bark, make it possible to shave off a very thin smooth slice, with no tearing or wounding below the surface. With a thick, fibrous bark as in Castilla, or a thin, hard bark as in Funtumia or Manihot, the same methods

*Ridley, H. N. *Agricultural Bulletin of the Straits and Federated Malay States,* No. 3, 1903, Vol. II, p. 112.

†Ridley, H. N. Historical Notes on the Rubber Industry. *Agricultural Bulletin of the Straits and F. M. S.* Vol. IX, No. 6, June, 1910, p. 202-3.

of making the cuts and collecting the rubber are not feasible.

To designate the special tapping method developed for Hevea a distinctive word is needed, that will avoid the ambiguity of such expressions as "renewed," "repeated," or "continued," since these words are equally applicable to tapping with separate cuts, and the trees are cut repeatedly under either system. To learn that it was possible to repeat the cuts in the same place, instead of opening new places on each occasion, was the essential feature of the discovery. The Latin word *ibidem*, meaning *in the same place*, is suitable for marking the distinction.

If Ridley had been taking out a patent he would have been compelled to reduce his discovery to words that would express and establish the distinction between his method of tapping and that proposed in Ceylon, in imitation of the native method in Brazil. The experiments in Ceylon showed the wound response at a distance from the previous cuts, while the experiments at Singapore showed that continued flows of latex, more abundant than at the first cutting of the bark, could be obtained from the same wounds, by shaving off the margins.

The words that have been used to describe the accepted method as renewed or repeated tapping are all ambiguous in not establishing any definite distinction between making more wounds and tapping continuously in the same place, which is the essential feature. Without this distinction even Ridley's statements regarding the work in Ceylon are easily misunderstood, as appearing to question the reality or the importance of the wound response, instead of stating the more pertinent and necessary objection to the method of tapping itself, which required the making of new cuts on each occasion.

The wound response can be shown by making new cuts between the preceding wounds as the custom is in South America, but it is at least very doubtful whether any plantation industry could have developed on the basis of that system of tapping. The cost of tapping with many separate wounds must have been greater, and in a few seasons the trunks of the trees probably would become too rough for tapping to continue, as in South America.

Twenty Years in Abeyance

An instructive feature of the rubber history is the period of twenty years that intervened between the introduction of Hevea in 1876 and 1877 and Ridley's announcement of a tapping method in 1897. The task of clearing the scrub around the Hevea trees at the Singapore Garden, in order to collect the seeds, as stated in the report for 1897, reflects a more active interest than in previous years. The imported Hevea trees had begun to fruit in 1881, allowing seeds and seedlings to be sent to various places, but many seed-crops seem to have been lost before active planting began. A few trees in Ceylon were tapped by Trimen in 1881 and 1882, but merely to see whether they contained good rubber, rather than to determine the quantity that could be obtained. A few planters of other crops had set out Hevea trees, but apparently in very small numbers.

Ridley's impatience with the planters for not going into rubber, seems hardly warranted, since practical reasons to justify large plantings were lacking until a method of tapping was assured. Millions of dollars were being placed with less caution in Castilla plantations in Mexico, that proved a total loss. The differences between Hevea and Castilla for plantation purposes were not recognized. The lack of any adequate experimental basis for the Mexican plantation development was shown in a publication of the U. S. Department of Agriculture, issued in 1903.* Accounts of the Mexican undertakings were published by Ridley, apparently as a means

*The Culture of the Central American Rubber Tree, Bul. 49, Bur. of Plant Industry, U. S. Dept. of Agriculture.

of stimulating interest and getting plantations established in Malaya.

Fictitious Objections

A psychological factor to be considered in this field of work is that any objections, no matter how fictitious or fantastic, are likely to seem good, at least to the extent of lessening interest and deferring action. Very intelligent people are subject to this curious tendency to take a side-track as soon as possible in considering any new idea, or projecting a new industry. Much time and effort is lost in working around these gratuitous notions that grow up like weeds in the empty spaces of our minds.

Several such instances are included in the Hevea history. To one it seemed foolish to undertake the cultivation of foreign rubber trees while there were native rubber vines growing in the forests. Difficulties encountered in early efforts with *Ficus clastica* were counted against the possibilities with Hevea. It was expected that Hevea would be propagated from cuttings because that method had been applied to Ficus. When good results began to be reported from the Hevea experiments there was a great boom of fictitious values in Castilla plantations in Mexico.

The episode of the British Resident ordering the Hevea trees cut down because they were condemned by Dyaks who knew how to tap upas trees, is an excellent example of the grotesque and gratuitous errors that infest the pathway of new undertakings. Of course, the natives should know! Several parallel cases have occurred in tropical America where plantings of Hevea trees were cut down because the latex did not flow freely at the first tapping as it does from the Central American rubber tree, Castilla. Reports of barren Hevea trees have been current in Central America and the West Indies, but surviving trees have been found later to contain normal quantities of latex. This mistake has interfered with the planting of Hevea in several countries where Castilla was a native tree and the methods of tapping Hevea were not known.

The use of rubber as a waterproofing material seems to have generated the idea that trees would be restricted to very wet climates, and to overflowed lands. Endless modifications of the tapping cuts and tapping tools were devised before settling down to the simple gouge and the single straight cut. Long intervals between tappings were supposed to be required, and wounds beyond a certain size were supposed to result in permanent injury to the trees. Ridley held at one time that tapping should be done in the afternoon, in order to obtain latex with a smaller proportion of water.

Costly methods of wide spacing of the trees and clean cultivation were applied in the East Indian plantations, probably to the detriment of the trees, so that now articles are appearing on "Rejuvenation of Old Rubber Estates." Elaborate milling machinery has been devised and erected on many estates, and complicated washing and curing processes, mostly not necessary and sometimes actually harmful to the rubber.

Each one of these notions, and many others that might be enumerated, carries with it the possibility of discouraging investigation or of taking a wrong turn at some critical point, and thus encountering unnecessary obstacles. At the present time it is considered impossible that any other kinds of rubber trees can be utilized, because the tapping method for Hevea does not apply, and alternative methods of extraction have not been developed. Also the production of rubber is greatly impeded by the notion that large plantations like those of the East Indies are necessary, though a rapidly increasing proportion of the rubber of the Dutch colonies is of native production.

Photograph by W. M. Boynton

THE PRIZE-WINNING HONEY LOCUST TREE

Figure 8

Located on the Goldworth Farm at Villa Rica, Ga. The photograph was made in late winter, after the crop of pods had been shed. Curiously enough, the tree is located on the edge of a gulley produced by erosion, of the kind that the culture of the Honey Locust would help to prevent.

THE HONEY LOCUST CONTEST

THE Honey Locust Contest closed on December 31, 1927. The four prizes were awarded at the annual meeting of the Council on January 17, the following individuals being adjudged the winners:

Miss Ellen Williams, Villa Rica, Ga., first prize, $30.00.

Frank Gerrard, Clemson College, S. C., second prize, $10.00.

Ira J. Condit, University of Calif., third prize, $5.00.

Miss A. C. Diden, Glen Mary, Tenn., fourth prize, $5.00.

It is regretted that all those who sent in samples could not have shared in the awards, but the letters and the samples of beans submitted have added considerably to our knowledge of the honey locust, and all who participated deserve our thanks for their help in bringing this information together. Thus far only a sugar analysis of the beans has been made, and we take this opportunity to thank Dr. Heinrich Hasselbring, U. S. Department of Agriculture, for making this.

Description of the Prize Winners

Beans of the winning trees are illustrated in the accompanying photographs. The Williams locust has beans from 14 to 16½ inches in length, and a breadth of over 1½ inches. The beans average about 17 to the pound, or just under one ounce per bean. There is little tissue surrounding the seeds, but the "back" of the bean is very thick, and this part has an excellent flavor and is remarkably rich in sugar—a chemical analysis showing a total sugar content of 29.7%. The Williams locust differs from all other entries in having nearly all the sugar localized in the "back" of the pod, while the tissue surrounding the seeds contains very little. The prize winning tree is located in a pasture belonging to the Goldworth Farm at Villa Rica, Georgia. There are two trees growing near each other that produce the same kind of large, sweet pods. The fresh pods are eaten eagerly by cattle and hogs, and Miss Williams describes them as "delicious," and says that an abundant crop is produced every year.

The Gerrard locust has a pod shorter and broader than the Williams. The dry pods average about 20 to the pound. The "back" of the bean is less thick than the Williams, and the sugar-bearing tissue occurs all the way across the bean. It is almost black in the sample submitted, while that of the others varies from amber to dark brown. Possibly this is due to slow drying or to some other difference in handling. Sugar content is 25.4%. The bean is relatively short and thick, averaging about 10 inches in length and two inches in breadth. The tree is located on land owned by Clemson College, on the banks of the Senica River near Fort Rutledge, South Carolina. The tree is not over six or eight years old, but bears heavily.

The Condit locust has a considerably smaller pod—average length about 11 inches; width about 1¼ inches; 37 beans to the pound. It is quite rich in sugar (25.4%), and has an excellent flavor. The tree is located at Visalia, California, and it is the most promising specimen in a row of honey locusts planted about twenty years ago. California is far beyond the natural habitat of the honey locust, but from letters received the species appears to thrive in many parts of the state.

The pod of the Diden locust is somewhat larger than the Condit, with a higher sugar content (29.5%), but with a rather puckery flavor. The tree is said to be a heavy bearer. It is located at Glen Mary, Tenn.

"Fatback" and "Razorback" Beans

One of the most interesting features brought out by the contest is the existence of two types of honey locust beans, which may conveniently be called

PRODUCTIVITY OF PRIZE-WNINING TREES

Figure 9

At the left is shown the tree that won second prize. Though only a young tree, it is loaded with pods. At the right is shown the first prize tree, which is reported to bear large crops of pods every year.

"Fatback" and "Razorback." The difference between them is as striking as that between a pure-bred Berkshire and a shoat in some backward community. All the fatback beans were sent from points in the southern United States, and it is yet to be learned whether this type is hardy in the northern range of the species. It may be that this represents a variation that does not withstand the lower temperature of the northern States.

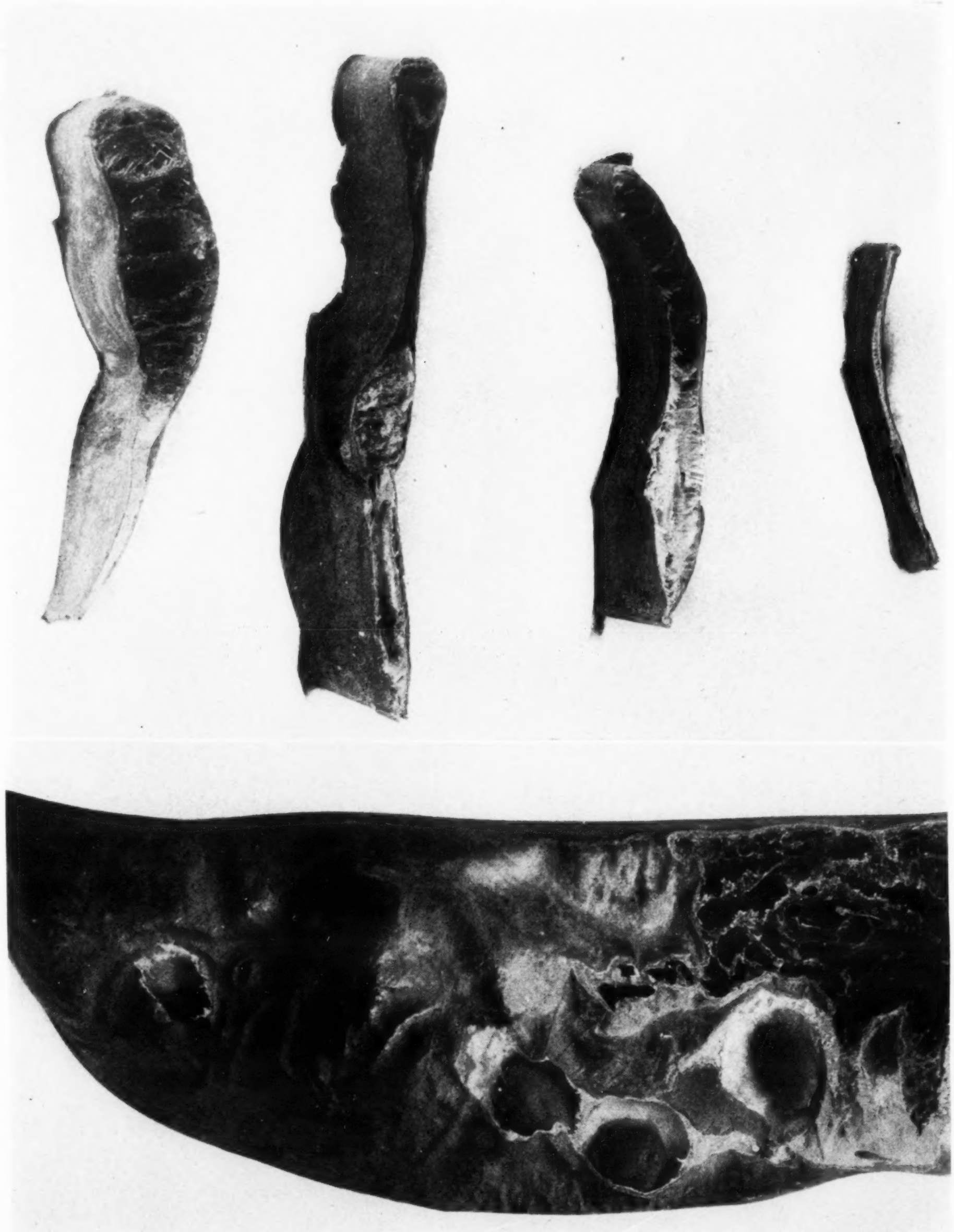
Distribution of Honey Locust

An important fact emphasized by the contest is the wide distribution of the honey locust. As reported in the JOURNAL a few months ago, this tree is found over a large part of the United States. Our note that it had not been reported from New England brought in a sample from Mrs. S. C. Damon of Kingston, Rhode Island, who tells us that in certain parts of that state the species is not uncommon. Many of the trees outside the natural range of the species have been chosen for their lack of thorns, so that the thornless variety appears to be the more widely distributed form.

Agricultural Possibilities

The literature on the honey locust is almost non-existent. In 1923 the United States Department of Agriculture reported a rather extensive study of the Mesquite Bean,* and in this were included analyses of a single sample of honey locust beans (containing 25.3% total sugar). These showed that the honey locust contained as much sugar as the carob and considerably more protein. As compared with the mesquite the honey locust contained 7% more sugar and 2% more protein. Rather

* WALTON, G. P., A Chemical and Structural Study of Mesquite, Carob and Honey Locust Beans. *U. S. Dept. of Agri. Bull.* 1194, 1923.



Photograph by Robert Cook

"FATBACK" AND "RAZORBACK" LOCUST PODS

Figure 10

Above are shown cross sections of the first, second and third prize winning pods, and at the right a pod of the more common "Razorback" type. The dark colored section in the "back" of the bean contains most of the sugar. Below is a transverse section of one of the first prize beans, showing the alveolar, sugar-bearing tissue and the seeds. (Somewhat enlarged.)

Photograph by Robert Cook

PORTIONS OF PODS—NATURAL SIZE

Figure 11

From the bottom, pods of first, second and third prize Honey Locust trees.

Photograph by Robert Cook

VARIATION IN SIZE OF POD

Figure 12

Two of the first prize pods compared with other entries in the contest. The longest pod was 16½ inches in length and weighed more than an ounce when dry.

AN OAK-TREE AGRICULTURE IN THE BALEARIC ISLANDS

Figure 13

On the Island of Majorca there is a variety of oaks which bear sweet acorns, highly prized for food by the Spanish inhabitants. The oaks that bear the edible acorns are a strain of the native evergreen oak (*Quercus ilex*, var. Bellota). The edible form is propagated by grafting on the wild trees. There are a number of the grafted trees of this oak growing back of the Monastery of Lluch, on the Island of Majorca. At the time of my visit in August 1925, the acorns were not ripe, but I am assured that they are as sweet as chestnuts.—*David Fairchild.*

Photograph by David Fairchild

TRUNK OF GRAFTED OAK TREE

Figure 14

The trunk of one of the trees bearing sweet acorns. The grafts appeared to be about ten years old. The stock is the wild astringent-fruited variety of the "Bellota" or evergreen oak of Majorca.

extensive milling tests were conducted to determine the feeding possibilities of mesquite beans. By separating the seeds and the pods (which contain the sugar bearing tissue) it was possible to make two kinds of meal, one high in sugar and the other in protein. Actual feeding tests with the mesquite in the Southwest and in Hawaii have proven its value as a stock feed. In fact, in Hawaii the mesquite, which was introduced in 1828, has assumed an important place in the agriculture of that island.

The pods are everywhere recognized as one of the most important grain feeds of the islands and are greatly relished by all kinds of livestock, including chickens. Their (the beans) feeding value has long been recognized from the practical results obtained. As a feeding material there seems to be only one objection to them, and that is a slight flavor given to milk when the beans are fed in excess to the dairy cows. This objection, however, could be overcome by feeding the beans after milking, rather than before milking.*

These results with mesquite do not prove the case for a related tree, the honey locust, but the evidence of the possibilities of the latter is convincing. Among the letters received in connection with this contest the statement that the beans are liked by cows and hogs is frequently met with. A few examples may be of interest:

> "The cows improve in milk and the hogs in weight when the locust ripens for there are always bushels and bushels of fruit on the tree."
>
> "The cows eat the beans as fast as they fall."
>
> "—and all bear an awful big crop of beans which the stock like so well that they will break down the fence to get them."
>
> "The cattle ate the pods I gave them with great relish."

Evidently the beans are of a flavor that would render them palatable as stock feed.

A recent announcement by the U. S. Department of Agriculture places the

annual loss from erosion at two billion dollars:

> The value of plant food wasted in the erosion or washing away of soils on the farms of the United States is estimated most conservatively by scientists in the United States Department of Agriculture as in excess of $2,000,000,000 a year. This estimate is based on the value of the principal chemical constituents, nitrogen, phosphoric acid, and potash, as they are purchasable in the cheapest kinds of commercial fertilizers and does not take into account the value of the soil as an agency for making use of these plant foods.
>
> This sum is more than 20 times the value of all the plant food removed by growing crops. The real "soil miner" is not the one who grows crop after crop of the same kind without replacing plant food, but rather the one who allows his precious soil to be washed away, his land to be gullied and destroyed, or the top-soil to be removed by sheet erosion. Some of the practices responsible for this tremendous annual loss, immediate and to posterity, are unwise clearing of areas which should remain in forest, unwise breaking for cultivation of sloping fields subject to erosion, unwise cultivation of soils that erode easily, and failure to terrace lands that could be saved by intelligent management.

Part of this loss is due to careless use of land that could be conserved by terracing and use of crop rotation. Much of it is brought about by the fact that we are attempting to cultivate large areas that should never have been under the plow. Tree crops offer the most promising solution to this menacing situation, and as a *forage tree* the honey locust has undoubted promise. The present contest has only served to call attention to some of the problems and to some of the possibilities. It has given us a glimpse of the alluring diversity that is offered the breeder of improved varieties. It is not too much to hope that some of the trees discovered by the contest may prove to be economically valuable themselves or that they will be the progenitors of better kinds produced by crossing some of tht superior wild individuals. Diversity offers the breeder a large number of characters that can be combined in many ways to suit varying needs, and this contest has emphasized the great range of possibilities that is offered in the honey locust.

The results are so encouraging that Professor J. Russel Smith, who contributed the prize money for this first contest, has signified his desire to learn whether we can find other trees that excel these prize-winners in yield, hardiness or food content. The terms of the new contest will be announced later. The wide distribution of this tree leads us to think that there must be many promising trees of which we have not heard.

Readers of the Journal are urged to make inquiry as to good bean trees and watch this paper for details of the new contest.

TABLE I—Sugar Content of Honey Locust Beans. Determinations by Dr. Heinrich Hasselbring.

No.	*Legend*	*Invert Sugar*	*Sucrose as Invert Sugar*	*Total Sugar expressed as Invert Sugar*
		%	%	%
1	E. Williams, Villa Rica, Ga.	5.4	24.3	29.7
2	F. H. Gerrard, Clemson College, S. C.	3.1	21.2	24.3
3	I. J. Condit, Tree No. 1	2.0	23.4	25.4
4	A. C. Diden, Glen Mary, Tenn.	4.0	25.5	29.5
5	I. J. Condit, Tree No. 3	7.0	14.6	21.6
6	J. B. Parsons, W. Va.	5.9	12.8	18.7
7	Rex Alley, Bethany, Mo.	1.4	11.5	12.9

EDITOR'S NOTE—The sugar content of sugar-cane ordinarily varies from 10 to 16 per cent; that of sugar beet from 12 to 18 per cent.

*For an excellent discussion of the possibilities of Tree Crop Agriculture see SMITH, J. R. Soil Erosion and its Remedy by Terracing and Tree Planting. *Science* (N. S.) 39: 858-862. June 12, 1914.

MARRIAGE STATISTICS FOR OBERLIN ALUMNAE

LOUIS D. HARTSON, *Oberlin College*

ARTICLES have appeared from time to time reporting the marriage rate among college women. Figures for Oberlin alumnae have been cited as representative of conditions in the older coeducational institutions. Data gathered for the Oberlin Alumni Catalogue of 1927 make possible a complete report on this subject. The editor, George M. Jones, has located and obtained responses from practically all of the living alumni. For the women graduates of the College of Arts and Sciences the report is 99.86% complete.

Table I presents a summary of the figures with reference to the marriages among this group of women.

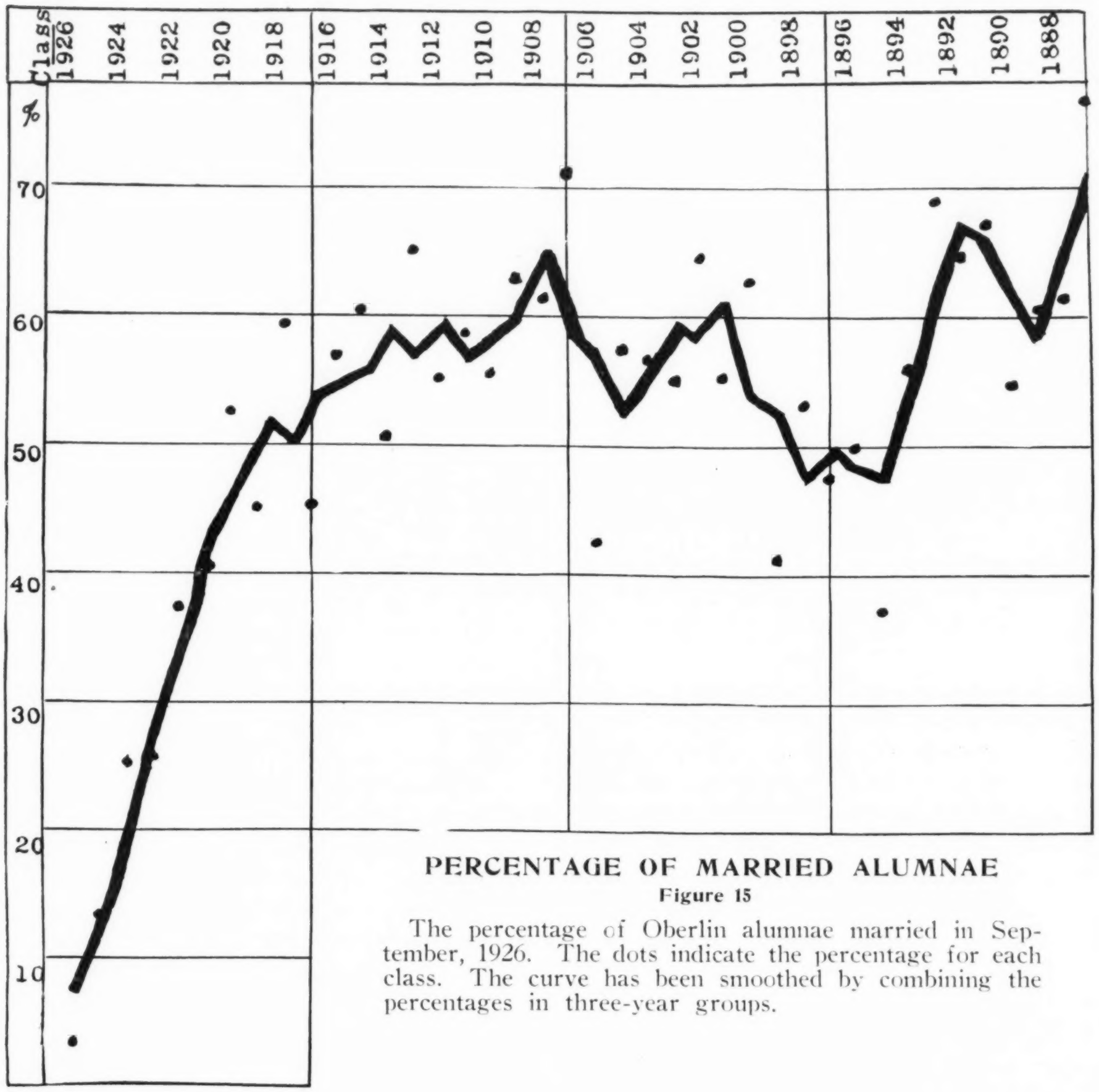
To make possible a more detailed examination of recent tendencies the figures for the last 40 years are given by years in Table II.

In Figure 15 the data of Table II are shown in a curve in which the percentages have been smoothed in three-year groups.

The marriage ratio, which was almost 100% during the first decade of the history of the college, declined steadily for 70 years, and reached its lowest point with the class of 1906, 42.1%. A compensating high level is presented, however, by 1907, the percentage for this class being 70.6%. Figure 15 shows that, when the 1906-07 upheaval is smoothed over, the marriage ratio has been fairly uniform since the beginning of the century. For the classes of 1900 to 1914 inclusive the per cent has been 58.3. A comparison of the alumni catalogue of 1916 with the present catalogue shows that since 1916, 5 women of the 1887-96 decade, and 21 of the 1897-06 decade have married during the last 10 years. It is to be expected, therefore, that about 60% of the women who have graduated since 1900 will ultimately marry. If it is safe to generalize from these data it would appear that (1) practically all of the marriages are now occurring during the first 12 years after graduation; (2) half of them occur during the first 3 or 4 years; (3) 8% of them (21 of the 267) marry during the third decade after graduation; (4) the marriage rate is highest during the period between the third and sixth year after graduation.

The median age at time of marriage is about 26. Five-sixths of the marriages occur before the women are 29. This is lower than the age of marriage reported by Miss Van Kleeck in 1918. She obtained responses from 71%, or 16,739, of the living alumnae of Barnard, Bryn Mawr, Mt. Holyoke, Radcliffe, Smith, Vassar, Wellesley, Wells and Cornell. The median age, as revealed by these responses, was 27 years and 3 months.[1] This contrast between the Oberlin figure for the last decade and the report for earlier years for these other colleges harmonizes with the findings of Newcomer and Gibson for Vassar, to the effect that the interval between graduation and marriage is decreasing.[2]

A significant matter of vital statistics was revealed by a comparison of the marriage ratio among the living alumnae with that among all of the women graduates. This is to be seen by comparing the fourth with the seventh column in Table I. It is shown more clearly by Table III. The difference in the death rate of the married and the unmarried women is very marked. For the entire 50-year period the difference in these two proportions is 33.4%. The proportion of the unmarried alumnae living in 1926 was 70% larger than the proportion of the



PERCENTAGE OF MARRIED ALUMNAE

Figure 15

The percentage of Oberlin alumnae married in September, 1926. The dots indicate the percentage for each class. The curve has been smoothed by combining the percentages in three-year groups.

married women still living. Homemaking has proved to be a much more hazardous occupation than the occupations in which Oberlin's unmarried alumnae have engaged.

Earlier studies seemed to warrant the conclusion that the rate of marriage is higher among alumnae of the coeducational institutions than it is among the graduates of the women's colleges, and Oberlin has been cited as one source of evidence. An editorial note which appeared 10 years ago in THE JOURNAL OF HEREDITY affirms: "It is now well known to eugenists that only from 40 to 50% of the graduates of the great women's colleges ever marry. . . . . Coeducation has often been suggested as likely to improve this condition, and several investigations of the marriage rate of women in coeducational institutions have been published which seemed to substantiate the claims."[3] The available data were then summarized and found to verify the inference. Robert J. Sprague's study is the source of the following marriage ratios: for the alumnae of Mount Holyoke, 41.9; for Bryn Mawr, 43.9; and for Vassar, 49%.[4] The figure for graduates of Wellesley is reported as 48%.[5] As representative of more recent tendencies, however, the figure for Wellesley alumnae for the five-year period, 1900-04 (in the year, 1916) is compared with that for the coeduca-

tional institutions. The report for Wellesley is given as 44; for Wisconsin, 44.5; for Illinois, 46.8; for Ohio State, 57; for Oberlin, 58.9; for California, 60.1; and for Kansas Agricultural College, 63.5%.[6] A subsequent report gives the figure, 69%, for Iowa State College.[7]

More complete data are now available which indicate that this contrast between the women's colleges and the coeducational institutions no longer exists, at least so far as Oberlin is representative of the coeducational institutions. The executive secretary of the Wellesley Alumnae, Laura M. Dwight, has sent the figures for that institution. The per cent of Wellesley alumnae who were married in 1926: for the years, 1879-89, 47%; 1890-99, 47%; 1900-09, 58%; 1910-19, 60%, and 1920-26, 29%. The latest figures for Smith College are: for the years 1879-88, 46.9%; 1889-98, 53.8%; 1899-08, 59.7%; 1909-18, 59.4%; 1919-25, 30.8%.[8] The Vassar statistics were gathered in 1922, viz: 1867-71, 61.9%; 1872-76, 55.6%; 1877-81, 52.9%; 1882-86, 59.1%; 1887-91, 53.3%; 1892-96, 53.2%; 1897-01, 58-7%; 1902-06, 59-5%; 1907-11, 61.4%; 1912-16, 46.6%.[9] These figures are based on returns from 79.3% of the alumnae. It is apparent from these figures that (1) the contrast between Oberlin and the women's colleges was one of the nineteenth century. Since 1900 there has been no marked difference between them. (2) Before 1900 the marriage curve in the two types of institutions was moving in exactly opposite directions. While at Oberlin the rate was declining, in the women's colleges it was rising. (3) At the present time the proportion of alumnae who marry is approximately 60% in all of these colleges.

Inasmuch as it has been suggested that the marriage rate is largely a matter of geography,[10] a statement should be made concerning the geographical sources of the Oberlin student body. The homes of the students enrolled at Oberlin last year were in *50 states and territories*, and 80 came from foreign countries. "For many years prior to 1907 the number of Oberlin students from the state of Ohio was exactly 50% of the total. between 1907 and 1910 the 'Ohio percentage' dropped from 50 to 45, and for thirteen years, beginning with 1909-10, the percentage of Ohio students did not vary from the 45% mark."[11] Inasmuch as the alumni are distributed over the country even more widely than are the homes from which they came to college, it may well be that the marriage rate among Oberlin alumnae is fairly typical of that for American women graduates.

Literature Cited

[1]*Journal of the Association of Collegiate Alumnae*, May, 1918, p. 579.

[2]Vital statistics from Vassar College, *The American Journal of Sociology*, Vol. XXIX, 430,42.

[3]The Journal of Heredity, VIII, 43-45.

[4]Op. cit., VI, 158-62.

[5]Op. cit., VI, 250-53.

[6]Op. cit., VIII, 44.

[7]Op. cit., VIII, 217.

[8]*Smith College Alumnae Quarterly*, February, 1926.

[9]*The American Journal of Sociology*, Vol. XXIX, p. 431.

[10]Goodsell, Willystine, The Education of Women, p. 44.

[11]Annual Report of the President of Oberlin College for 1925-26, p. 28.

TABLE I—Number of Oberlin Alumnae and the Percentage who have Married

Classes	*Number of alumnae*	*Number who have married*	*Percent who have married*	*Number now living*	*Number of living alumnae married*	*Percent of living alumnae married*
1837-46	80	78	97.5	0		
1847-56	129	104	80.6	0		
1857-66	276	215	77.8	40	23	57.5
1867-76	218	149	68.3	123	65	52.8
1877-86	282	195	69.1	207	131	63.9
1887-96	399	243	60.9	323	171	52.9
1897-06	507	267	52.6	461	224	48.5
1907-16	1035	616	59.5	998	559	56.0
1917-26	1338	394	29.4	1330	392	29.5

TABLE II—Marriage Figures for the Classes, 1887-1926

Classes	*Number of alumnae*	*Number who have married*	*Percent who have married*	*Classes*	*Number of alumnae*	*Number who have married*	*Percent who have married*
1887	38	29	76.3	1907	85	60	70.6
1888	41	25	61.9	1908	89	55	61.8
1889	48	29	60.4	1909	81	51	62.9
1890	46	25	54.3	1910	90	50	55.6
1891	37	25	67.6	1911	115	67	58.3
1892	42	27	64.3	1912	122	67	54.9
1893	45	31	68.9	1913	133	87	65.4
1894	57	32	56.1	1914	97	49	50.5
1895	19	7	36.8	1915	113	68	60.2
1896	26	13	50.0	1916	110	62	56.4
1897	38	18	47.4	1917	115	52	45.2
1898	40	21	52.5	1918	131	77	58.8
1899	58	24	41.3	1919	100	45	45.0
1900	43	27	62.8	1920	134	70	52.2
1901	45	25	55.6	1921	133	54	40.7
1902	42	27	64.3	1922	138	52	37.7
1903	58	32	55.2	1923	162	42	25.9
1904	48	27	56.3	1924	147	37	25.2
1905	59	34	57.6	1925	156	20	12.8
1906	76	32	42.1	1926	124	4	3.2

TABLE III—Proportions of the Married and of the Unmarried Alumnae Living in 1926

Classes	*Number who married*	*Number married alumnae*	*Percent married alumnae*	*Number unmarried alumnae*	*Number unmarried alumnae living*	*Percent unmarried alumnae living*
1857-66	215	23	10.6	61	17	27.8
1867-76	149	65	43.6	69	58	84.0
1877-86	195	131	67.1	87	76	87.3
1887-96	243	171	70.3	156	152	97.4
1857-96	802	390	48.6	373	303	81.2

FOOT-POSITION IN HOMO SAPIENS

Statistics of Foot-position in Eleven Thousand Women Shows Rarity of Primitive "Pigeon-toed" Position

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THE primeval ancestors of the human species walked on all fours, or in other words were true quadrupeds. Those of the group which branched off to finally constitute the species *Homo sapiens* gradually acquired the upright habit in locomotion, becoming bipeds. In the Quadrumana, the feet are curved inward and because of this serve better for the grasping of the branches of trees. Apes and monkeys of the present age, when walking on the ground, are pigeon-toed, so to speak, and bear the weight of the body largely on the outer edges of their feet. Figure 16, from a photograph taken of a chimpanzee in the New York Zoological Park pictures the condition described above. Figure 17 shows this strong inward reflection of the feet of an infant human child when three weeks old as it hung by its hands from a stick.

It is interesting to note the change of this situation in adult human beings, after the species has followed the course of walking in the upright position during the long period of its existence. It is of interest also to observe whether or not such factors as age, height, weight and so forth in groups of individuals are effective in altering the foot-position with respect to what it is in the general population. Data have been taken on the feet of approximately eleven thousand women. The observations were made over a period of years as a sort of pastime for filling up spare hours while keeping appointments in various cities of the United States. The technique was simply that of stationing oneself on busy street corners, observing as closely as possible the feet of the women as they went by, and registering the observations by means of three Veeder counters concealed in the pockets of one's coat.

Data were taken on white women only. If the feet or legs were obviously deformed in any way, the specimen was rejected. Other cases, as where the two feet were not the same in position (quite frequent in occurrence), or the distinction in position was too fine to be drawn, were also left out.

In the main, the feet of the modern human being, when standing or walking, take one of three positions. Either they reflect inward (pigeon-toed), or are straight, or else reflect outward. Three three positions are shown in Figures 18 and 19. The following data show the relative prevalence of the three positions among white women of different classes:

Table I.—Foot-position of 1,030 women of the general run, 18 years and upward of age

Position of feet	*Number*	*Percentage of total*
Straight	548	53.2
Turned inward	55	5.3
Turned outward	427	41.5

Among women in general, the normal seems to be a predominance of straight feet, fewer turned outward, and a scattered few turned inward or still of the position similar to that of the aboriginal. This scarcity of pigeon-toed persons accounts for the fact that individuals possessing this character usually attract our attention and draw our comments.

Naturally, the question arises as to how firmly these ratios in foot-position are fixed at the present time. Do they hold for all particular classes of women or are they subject to significant varia-

Photograph by E. R. Sanborn

FOOT POSITION IN THE CHIMPANZEE

Figure 16

Note the extreme "Pigeon-toe," characteristics of the primate foot. This position is excellently adapted for climbing, but for walking the human foot is better placed. Courtesy of the New York Zoological Society.

FOOT POSITION IN AN INFANT
Figure 17

Showing the soles turned toward each other, though not as much as is easily possible. Many babies have no difficulty in bringing the soles of the feet together, with the legs extended, an accomplishment totally out of the question for most adults.

tions under certain influences, such as height, weight or age of the body, which prevail during the lives of individuals? The following tables will serve to give light on this question.

Influence of Height of Body

By grouping women into two classes (tall and short) and noting foot-position the results shown in Tables II and III were secured.

Table II.—Foot-position of 1,021 short women of all ages above 18 years, regardless of weight

Walking Position of feet	*Number*	*Percentage of total*
Straight	561	54.9
Turned inward	97	9.5
Turned outward	363	35.6

Table III.—Foot-position of 1,017 tall women of all ages above 18 years, regardless of weight

Walking Position of feet	*Number*	*Percentage of total*
Straight	548	53.2
Turned inward	55	5.3
Turned outward	427	41.5

Obviously, height of body is not an effective factor. None of the differences shown in Tables II and III are great enough to have any degree of significance.

Influence of Age on Foot-Position

It might be surmised that since, with increasing age, the muscles of the body tend to relaxation and the loss of tension with respect to their control over the bones and skeletal joints, age may occasion relative changes in foot-position. Data bearing on this phase of the question are presented in Tables IV and V.

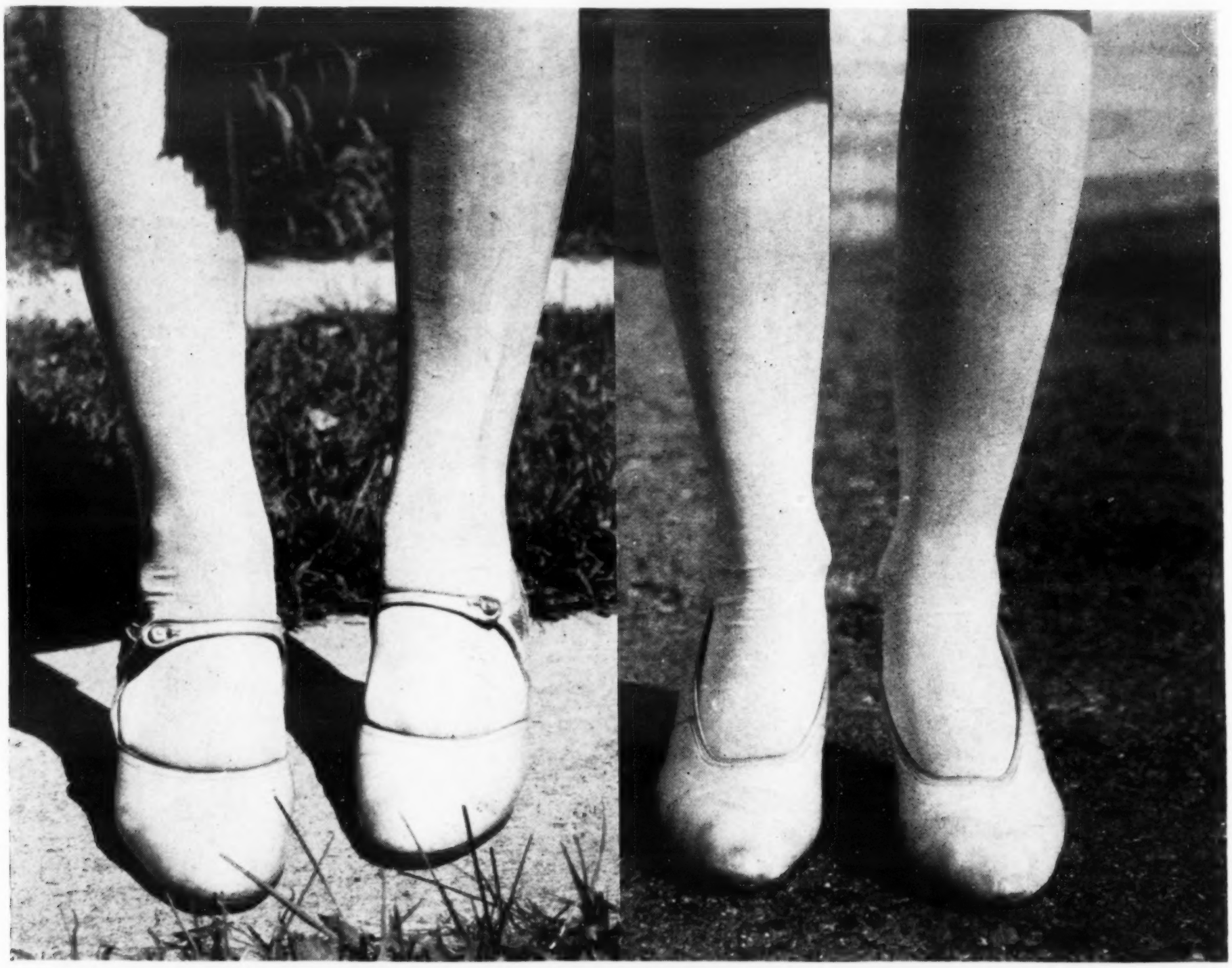
Table IV.—Foot-position of 1,054 older women above 40, regardless of build

Walking Position of feet	*Number*	*Percentage of total*
Straight	227	21.5
Turned inward	54	5.2
Turned outward	773	73.3

Table V.—Foot-position of 1,052 younger women (18-40 years of age), regardless of build

Walking Position of feet	*Number*	*Percentage of total*
Straight	572	54.3
Turned inward	72	6.9
Turned outward	408	38.8

The figures in Table IV indicate a striking departure from the situation shown in Table I. The percentage of pigeon-toed feet is the same as with women in general but the predominance of feet turned outward among older women is clearly manifest. This does



"PIGEON-TOES" AND PARALLEL FEET

Figure 18

In-turned feet (left) appear to represent the primative position of the human foot, now found in less than ten per cent of women. The parallel position of the feet is the one most frequently encountered, being found in about half the women over eighteen years of age.

not appear with younger women (Table V), the distribution being essentially the same as shown in Table I, except for a slight tendency towards more straight feet; a thing to be expected since older women were included in the data of Table I and are fewer in number than younger women in almost any throng on the street.

Naturally, the age limits set can not be followed with exactness for the problem of determining the age of a modern woman on sight is not an easy one. However, their camouflages are not as successful under a quiet, dispassionate eye as they may imagine.

Influence of Weight of Body

Thus far, it looks as though age is a strong factor, affecting the outward turning of the feet. Nevertheless, the weight of the body and its distribution may be influential also, since the feet form the base of the two pedestals supporting the trunk and head. Tables VI and VII give data showing the proportions of heavy and light individuals among older and younger women.

Table VI.—Proportion of heavy and light women among 1,020 older women, above 40 years of age

Class	*Number*	*Percentage of total*
Heavy	611	59.9
Light	409	41.1

Table VII.—Proportion of heavy and light women among 1,056 younger women, 18-40 years of age

Class	*Number*	*Percentage of total*
Heavy	119	11.3
Light	937	88.7

OUT-TURNED FEET
Figure 19

A position of the foot found predominantly among heavy women, apparently an adaptation to aid in balancing and supporting the increased weight.

Clearly, women become heavier with increasing age. Hence, one of the principal reasons for their fear of the consequences of growing older. Is it age as such or the heaviness that accompanies age which operates as the factor influential in turning the feet outward? Data shown in succeeding tables will give an answer to this question.

Table VIII.—Foot-position of 1,049 heavy women of all ages above 18 years

Walking Position of feet	*Number*	*Percentage of total*
Straight	211	20.1
Turned inward	37	3.6
Turned outward	801	76.3

Table IX.—Foot-position of 1,040 light women of all ages above 18 years

Walking Position of feet	*Number*	*Percentage of total*
Straight	661	63.6
Turned inward	70	3.8
Turned outward	339	32.6

Tables VIII and IX make it obvious that weight of the body is a factor. As heaviness increases with age the feet respond by turning outward. Separation of the two factors (age and weight) was accomplished to some degree by obtaining data on older, heavy women and also on older, light women. These data are presented in Tables X and XI. Like data were not gathered for younger women because of the scarcity of heavies among them. This scarcity is so great that the data in Table V may be compared with that contained in Tables X and XI.

Table X.—Foot-position of 1,014 older (above 40), heavy women

Walking Position of feet	*Number*	*Percentage of total*
Straight	150	14.8
Turned inward	45	4.4
Turned outward	819	80.8

Table XI.—Foot-position of 886 older (above 40), light women

Walking Position of feet	*Number*	*Percentage of total*
Straight	475	53.6
Turned inward	52	5.9
Turned outward	359	40.5

Unmistakably, the number of older heavy women whose feet turn outward is far greater than that of those who are older but less heavy. Therefore, it appears that it is not altogether a matter of age *per se* but one of weight, the weight being a development concomitant with increasing age. In other words, here may be an adaptation of the foot as a base of the pedestal forced to carry a heavier load and maintain the best balance for this load. It is easy to see that the upright habit of walking would tend to flatten and straighten the foot, but not so obvious that this would cause the foot to evolve past the straight position and flare outward. Increased weight in conjunction with the upright habit may be the explanation of this phenomenon. A physicist may be able to demonstrate that the feet when turned outward are more efficient in carrying and balancing the heavy and unequally distributed load of a heavy woman than straight feet or

feet turned inward. I have not attempted such a calculation.

Conclusion

From the original foot position (Figure 16) the feet of the female of *Homo sapiens* have flattened, and ceased to turn inward at the toe end except for scattered individuals amounting to less than one in ten of the total number of persons observed. In the process of evolution the feet even swing past the straight position to a considerable extent; feet that turn outward being decidedly predominant in certain classes. Weight seems to be the main characteristic of body associated with the outward turning of the feet during the individual's life time. The correlation with older age is probably only apparent and vanishes upon consideration of the fact that older women average heavier than younger.

The Preservation of Native Races

THE CLASH OF CULTURE AND THE CONTACT OF RACES, by GEORGE HENRY FOX-LANE PITT-RIVERS. Pp. 341. Price 18 shillings. Geo. Houtledge & Sons, London, 1927.

IN the words of the sub-title this is "an anthropological and psychological study of the laws of racial adaptability, with special reference to the depopulation of the Pacific and the government of subject races." The author gives a well-documented critical review of each of the many causes and alleged causes of the depopulation of the native races of the Pacific. In conclusion some practical suggestions are made as to what he considers the best methods of preserving both the native races and their culture.

The readers of the Journal would probably be interested most in the discussion of the sex-ratio, infant mortality, inbreeding, and polygamy. There is also a suggestive though inconclusive short section upon the possible effects of psychological attitudes and the will to live upon fertility and racial survival. The discussion of inbreeding, like practically all discussions of this subject, leaves out one important factor, viz., the incest taboo as a social safeguard against sex looseness within the necessarily promiscuous family circle.

The dilemma, as it presents itself to the author is this: Contact with white culture being inevitable, how can it be made least lethal? Such contact leads to the disintegration of the native culture and this disintegration in turn leads to racial decline and depopulation.

As a way out of the dilemma, he recommends two immediate measures. First, before attempting to administer the affairs of a "subject race," study thoroughly the native culture. The science of anthropology can help here. Secondly, minimize the contact and destroy as little of the native culture as possible. Eschew missionary labors and European education. Support all native customs that may be necessary to preserve the integrity of native culture, including such customs as magic and sorcery [with their correlate, blood revenge?], polygamy and polyandry, slavery, and headhunting. The reviewer's personal field contact with half a dozen native Indian tribes, leads him to wonder if the solution of the dilemma is so simple as all this.

John W. Cooper.

MENDELIAN INHERITANCE OF LEAF SHAPE IN COTTON

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COMPARATIVELY few instances of segregation in definite Mendelian ratios have been reported for cotton hybrids and, so far as the writers know, leaf lobation is the only character showing clear-cut monohybrid segregation without pronounced dominance of one or the other parental condition.* Leake[3] crossed two species of Indian cottons (*Gossypium indicum.* and *Gossypium arboreum*) one of which has a deeply and narrowly lobed leaf and the other a shallowly and broadly lobed leaf. The first generation plants were intermediate and the second generation segregated in a 1:2:1 ratio, half of the plants having been intermediate, like the first generation, one-quarter having resembled the narrow-lobed parent and one-quarter the broad-lobed parent. Similar results were obtained by Shoemaker[5] and by McLendon[4] in crossing two forms of Upland cotton, one deeply and narrowly lobed ("Okra-leaf" type) and the other having the shallow and broad lobes characteristic of most Upland cottons.

Crosses made by the writers between an "Okra-leaf" form of Acala cotton (Figure 21)† and the normal, broad-leafed form of the same variety (Figure 20) gave results like those of preceding investigators. In leaf-lobation, all of the first generation plants and approximately half of the second generation plants were intermediate between the narrow-lobed and the broad-lobed parent (Figure 20) while the remainder of the F_2 population was almost equally divided between the okra-leaf type and the normal Acala type. The segregation in F_2 was so clear-cut that there was no difficulty whatever in classifying any of the individuals by inspection in the field. For 80 plants comprising the F_2 population, the distribution which could be expected with a 1:2:1 ratio and the distribution actually observed are shown in Table I.

The deviation from a 1:2:1 ratio is negligible, the value of x^2 being 2.47, which indicates chances of about 1 in 3 that the departure from the expected distribution is not greater than would be expected with random sampling.

The classification was checked further by determining the "leaf-lobe index‡ of all parental and hybrid plants. Five leaves were measured on each plant and the average of the five indices computed from these measurements was taken as the leaf-lobe index of the plant.

The means and ranges for lobe-index of the several classes of plants are shown in Table II. (see also Figure 22): The means of the three classes in F_2 do not differ significantly from those of the corresponding parental and F_1 populations. The midpoint between the

*Another character which perhaps should be regarded as showing absence of pronounced dominance is leaf color, in crosses between green-leaf and red-leaf cottons.

†The origin of this form and its agricultural possibilities are described by O. F. Cook and C. B. Doyle[1] (p. 23). "Okra leaf" probably is to be regarded as a recurrent mutant since it has appeared independently in several normally broad-lobed varieties of upland cotton.

‡The leaf-lobe index, as defined by T. H. Kearney,[2] (p. 7) is "the distance from the base of the blade to the bottom of the sinus between the terminal lobe and the upper right-hand lateral lobe, expressed as a percentage of the length of the leaf. A high lobe-index indicates a shallow-lobed leaf and vice versa." Leake[3] used as an expression of the leaf-lobation what he terms the "leaf factor," i. e., the length of the leaf blade minus the distance to the upper sinus, divided by the maximum width of the middle or terminal lobe. It is not improbable that F_1 of the cross here described would have given a more nearly intermediate value for the "leaf factor" of Leake than for the "lobe index" as used in this paper.

LEAF OF ACALA COTTON AND OF HYBRID WITH OKRA LEAF VARIETY

Figure 20

At left, the shallowly and broadly lobed leaf of the normal Acala parent. In crosses with the okra-leaf variety of Acala (Figure 21) approximately one-quarter of the second generation hybrid plants had leaves of this type. At right, the leaf-type, intermediate in depth and width of lobes, which characterized all of the first generation and approximately one-half of the second generation hybrid plants.

LEAF OF NARROW-LEAVED ("OKRA-LEAF") ACALA COTTON

Figure 21

The deeply and narrowly lobed leaf of the Okra-leaf Acala parent. In crosses with the normal-leaved type approximately one-quarter of the second generation hybrid plants had leaves of this type—one of the few instances of simple Mendelian inheritance to be reported in cotton.

parental means (8.9 and 43.0) being 26, the means of F_1 and the intermediate class in F_2 are somewhat nearer to the mean of the narrow-lobed parent than to the mean of the broad-lobed parent. The ranges, as given in the table, illustrate the sharpness of the segregation, there having been no over-lapping between the several classes.

The vein-angle of the leaf has been defined[2] (p.8) as the "width, in degrees, of the angle subtended by the principal lateral veins." In previous investigations, this character was found to be negatively correlated with the lobe-index. Deeply lobed leaves, whose lobe-index is low, tend to have a wide vein-angle and vice versa. The same correlation holds good in the present material, as is shown by the means for vein-angle of the three classes of F_2 plants. The mean vein-angle of the narrow-lobed (okra-leaf) class was 130, of the intermediate (F_1) class 105 and of the broad-lobed class 93. All of these means differed significantly, the smallest difference (between the intermediate and the broad-lobed class) having been nearly 6 times its probable error

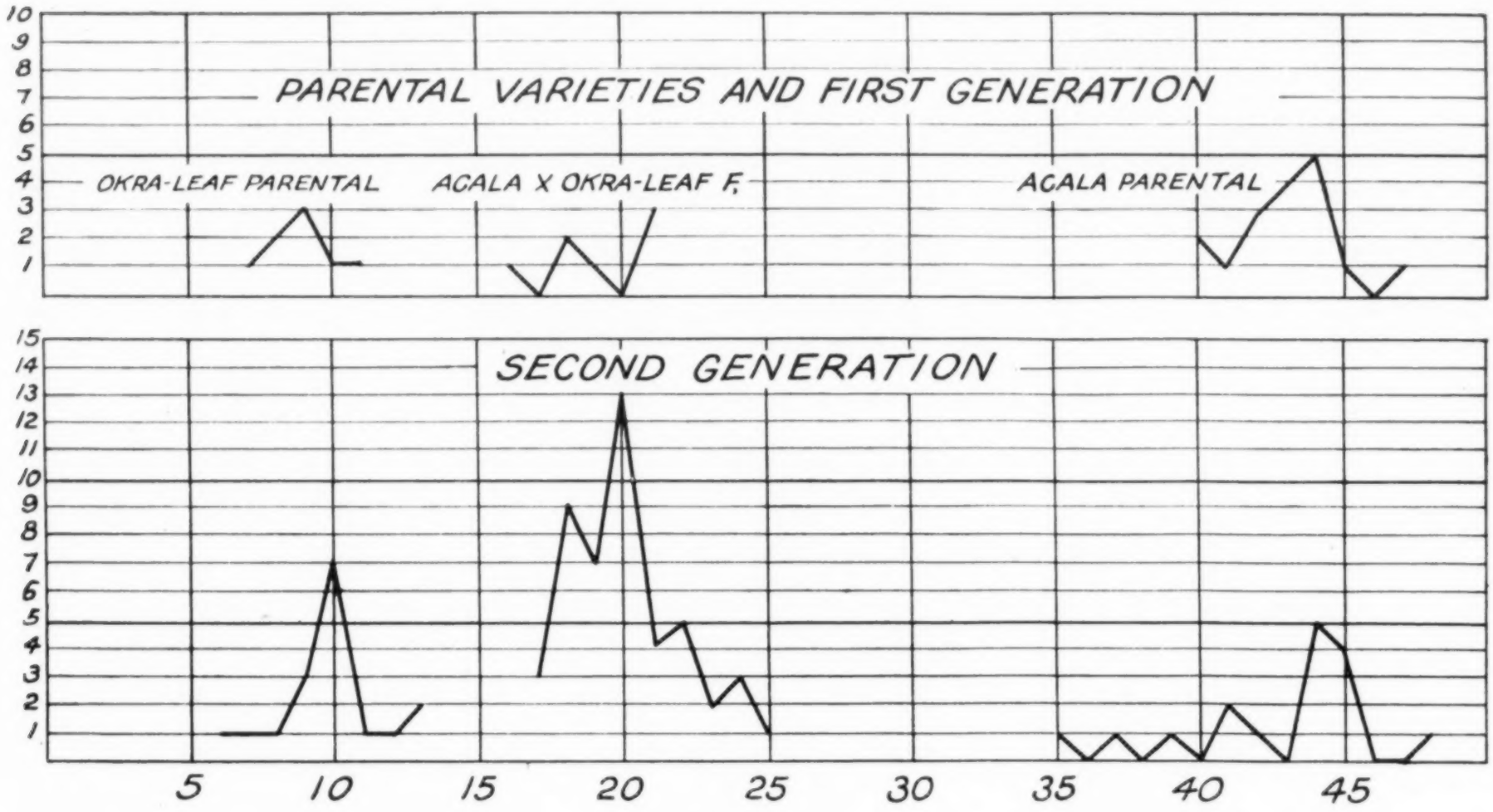

Figure 22

Showing the intermediate nature of the F_1 plants and the clear-cut segregation in the second generation.

TABLE I—Distribution of F_2 Plants, Normal × Okra-Leaf Acala

	Narrow-lobed (Okra-leaf) type	*Intermediate (F_1) type*	*Broad-lobed (normal-Acala) type*
Expected	20	40	20
Observed	17	47	16

TABLE II—Means and Ranges of Leaf-Lobe Index of Parent Plants and Hybrids

	Narrow-lobed (Okra-leaf) type		*Intermediate (F_1) type*		*Broad-lobed (Normal Acala) type*	
	Mean	*Range*	*Mean*	*Range*	*Mean*	*Range*
Parents and F_1	8.9±0.31	7-11	19.1±0.57	16-21	43.0±0.29	40-47
F_2	9.8±0.31	6-13	20.1±0.20	17-25	42.7±0.58	35-48

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